CHAPMAN LAKE
DIAGNOSTIC STUDY
Kosciusko County, Indiana

June 8, 2001

Prepared for:
Chapman Lake Conservation Association, Inc.
P.O. Box 776
Warsaw, Indiana 46581
(219) 267-7666

Prepared by:

J.F. New & Associates, Inc.
c/o Marianne Giolitto, Project Manager
708 Roosevelt Road
Walkerton, Indiana 46574
(219) 586-3400

School of Public and Environ. Affairs
c/o Bill Jones, Principal Scientist
Indiana University
SPEA 340
Bloomington, Indiana 47405

CHAPMAN LAKES DIAGNOSTIC STUDY
EXECUTIVE SUMMARY

Big Chapman Lake and Little Chapman Lake are natural lakes located approximately 5 miles northeast of Warsaw, Indiana in the southern portion of Kosciusko County. Together the lakes have an area of 638 acres (258 ha). The lakes' watershed encompasses approximately 4,500 acres (1,822 ha) or 7 square miles (18 km^2). Nearly 60% of the land in the watershed is used for agricultural purposes, including cropland and agricultural woodlots. The next two most predominant land uses are open water (13.1%) and wetland (11.5%) with forested, residential, and pasture composing the remaining 15% of the watershed land usage. An analysis of hydric soils in the watershed suggests that approximately 49% of the original wetland acreage exists today. Only 50 acres of land in the watershed is mapped in a highly erodible soil unit; however, nearly 40% of the watershed is mapped in a potentially highly erodible soil unit.

The Chapman Lakes have five main inlets some of which are dry during low flow conditions: Island Park Drain, Crooked Creek, Arrowhead Park Drain, Highland Park Drain, and Lozier's Creek. In general during low flow conditions, inlets contributed little nutrient or sediment loading to the lakes, although some sites did exhibit elevated concentrations of total phosphorus and *Escherichia coli* (*E. coli*) bacteria. During storm flow Lozier's and Crooked Creek added the largest amounts of pollutants to the lakes. Suspended solid loading and *E. coli* loading were greatest from Crooked Creek, while ortho-phosphorus loading was most pronounced from Lozier's Creek. Crooked Creek delivered the most sediment, total phosphorus, and bacteria per acre of watershed. At base flow conditions, the Highlands Park inlet also contributed substantial amounts of the pollutants despite having a relatively small watershed.

Big Chapman Lake is best classified as a mesotrophic lake. The lake seems to fit this description as it supports only moderate rooted plant growth with moderately clear water. Bluegill and bass dominate the lake's fish community, while a diverse mix of native pondweeds, eel grass, and emergent vegetation grows in patches throughout the lake. Big Chapman Lake generally has better water quality than most other Indiana lakes. Phosphorus concentrations, however, appear to be increasing since the mid-1990s, while the percentage of the water column containing oxygen appears to have been decreasing recently. Volunteer lake monitoring data indicates that the Secchi disk transparency of Big Chapman Lake is holding steady or slightly decreasing. In general, trophic state indices and water quality parameters indicate that although water quality in Big Chapman Lake is good, concern for worsening conditions is warranted. Phosphorus modeling of Big Chapman Lake and its watershed suggests that 22% of the phosphorus in the lake originates from internal sources.

Little Chapman Lake is a eutrophic lake with some rooted macrophyte problem areas and relatively poor transparency. As is characteristic in many eutrophic systems, bluegill and gizzard shad have historically composed most of the fish biomass. Little Chapman Lake also tends to have worse water quality than most other Indiana lakes and more problems with the invasive Eurasian watermilfoil. While mean historic total phosphorus concentrations in the lakes have shown a slight decreasing trend in the past decade, Secchi disk transparencies have been decreasing. The same phosphorus modeling procedure for Little Chapman Lake indicates that 37% of total phosphorus loading originates from internal sources.

The two Chapman Lakes are different with respect to physical characteristics as well. For example, Little Chapman Lake flushes or replaces its water about three times per year and is affected by a larger watershed than Big Chapman Lake. Although Big Chapman Lake currently has better water quality than Little Chapman Lake, it takes two years to flush its water. Due to the shorter flushing rate of Little Chapman Lake, it can respond more quickly to improvements within its watershed. By the same token, because Big Chapman Lake takes longer to flush, more serious, long-lasting problems may result if watershed and recreational use issues are not quickly addressed.

Although water quality in Big Chapman Lake is relatively good, it is a valuable resource meriting conservation. Additionally, management efforts applied to Big Chapman Lake will also improve Little Chapman Lake since its water discharges to Little Chapman Lake. Improvements can be achieved by implementing a variety of management strategies with first priority given to the Crooked Creek subwatershed. These include implementing bank and channel erosion control techniques, installing Best Management Practices (BMPs) and restoring wetlands within the watershed, and employing stormwater treatment and conservation design in new development areas. Lozier's Creek subwatershed and Arrowhead Park subwatersheds of Little Chapman Lake are also priority targets for the implementation of various management recommendations. Specific locations for the implementation of these management techniques are outlined in the study.

ACKNOWLEDGMENTS

This Diagnostic Study was performed with funding from the Indiana Department of Natural Resources - Division of Soil Conservation and the Chapman Lakes Conservation Club (CLCC). The team of J. F. New and Associates, Inc. and Indiana University - School of Public and Environmental Affairs documented the historical information available, completed lake and tributary stream sampling for nutrient and sediment loading, analyzed resident survey data, and modeled nutrient export to the lakes. Significant contributors to this study included Samuel St. Clair and Julie Harrold of the Kosciusko County Soil and Water Conservation District. Special thanks are due Chapman Lake property owners Dan Lee, Greg Hall, Tom Ross, and Joel Wihebrink for their initiative and assistance in getting this study completed. Members of the CLCC survey task force donated their time and effort to collecting lake recreation and lake usage data, both of which will aid in future management recommendations. Jill Hoffman, Jed Pearson, Bob Johnson and numerous others assisted with their comments and contributions on historic lake activities. Authors of this report include William Jones, Melissa Clark, and Jan Hosier at Indiana University, and Marianne Giolitto, Cornelia Sawatzky, John Richardson, and Steve Zimmerman at J. F. New and Associates, Inc. Brian Majka of J.F. New and Associates, Inc. provided GIS maps of the study area.

TABLE OF CONTENTS

Introduction....1
Resident Survey....3
- Methods....3
- Results....5
- Discussion....20

Watershed Physical Characteristics....22
Climate....25
Soils....26
Land Use....36
Wetlands....39
Natural Communities and Endangered, Threatened, and Rare Species....42
Shoreline Development....43
Inlet Stream Sampling....45
- Background Information and Methods....45
- Results and Discussion....47

Lake Morphometry....51
Historical Water Quality....56
In-Lake Sampling....65
- Methods....65
- Results....67
- Discussion....73

Fisheries....80
- Big Chapman Lake....81
- Little Chapman Lake....84

Unionids....87
Aquatic Macrophyte Survey....89
- Historical Macrophyte Reports....92
- Current Survey Results....93
- Discussion and Summary....95
- Aquatic Plant Management....97

Water Budget....105
Phosphorus Budget....108
Watershed Management....114
- Crooked Creek Subwatershed....114
- Lozier's Drain Subwatershed....119
- Arrowhead Park and Highlands Park Drain Subwatersheds....120
- Shoreline/Near Shore....120

In-Lake Management....123
Recommendations....125
Literature Cited....128

TABLE OF FIGURES

1. Location Map 2
2. Residential Areas Covered by the 2000 Lake Resident Survey 4
3. Number of Surveys Collected Around the Chapman Lakes 5
4. Time During Year that Lake Residents Occupy Homes 6
5. Types of Homes Owned by Lake Residents 7
6. Ages of Homes Owned by Lake Residents 7
7. Ages of Septic Systems Owned by Lake Residents 8
8. Frequency With Which Chapman Lakes are Used by Lake Residents 9
9. Percentages of Lake Residents Participating in Recreational Activities 10
10. Percentages of Lake Residents Owning Different Types of Boats 11
11. Percentages of Lake Residents Owning Different Numbers of Boat Types 11
12. Length of Time Lake Residents Have Perceived a Decrease in Water Clarity 12
13. Length of Time Lake Residents Have Perceived an Improvement in Water Clarity 13
14. Length of Time Lake Residents Have Perceived an Improvement in the Fishery 14
15. Length of Time Lake Residents Have Perceived a Deterioration in the Fishery 14
16. Percentages of Lake Residents Reporting Problems in Their Area of the Lake 15
17. Length of Time Lake Residents have Perceived Sediment Accumulation in Their Area of the Lake 16
18. Length of Time Lake Residents have Perceived Plant Accumulation in Their Area of the Lake 17
19. Percentages of Lake Residents Responding to One of Four Specific Issues as the Biggest Problem 18
20. Percentages of Lake Residents Responding to an Open-Ended Question on Lake Problems 19
21. Best-Liked Qualities of the Chapman Lakes 19
22. Topographical Map of the Chapman Lakes Watershed 23
23. Chapman Lakes Subwatersheds Map 24
24.a. Soil Map 27
24.b. Soil Map Legend 28
25. Highly Erodible and Potentially Highly Erodible Soil Map 29
26. Highly Erodible Land Tracts in the Chapman Lakes Watershed 31
27. Soil Types Adjacent to the Chapman Lakes 33
28. Land Use in the Chapman Lakes Watershed 37
29. National Wetland Inventory Map of the Chapman Lakes Watershed 40
30. Hydric Soil Map 41
31. Inlet Stream Sampling Location Map 46
32. Bathymetric Map of the Chapman Lakes 52
33. Depth-Area Curve for Big Chapman Lake 54
34. Depth-Volume Curve for Big Chapman Lake 54
35. Depth-Area Curve for Little Chapman Lake 55

36. Depth-Volume Curve for Little Chapman Lake 55
37. Historic Total Phosphorus Data for Big Chapman Lake 58
38. Historic Total Phosphorus Data for Little Chapman Lake 58
39. Secchi Disk Transparency Trend, Big Chapman Lake 59
40. Secchi Disk Transparency Trend, Little Chapman Lake 59
41. Historic Dissolved Oxygen Profiles, Big Chapman Lake 60
42. Historic Dissolved Oxygen Profiles, Little Chapman Lake 61
43. Dissolved Oxygen and Temperature Profiles, Big Chapman Lake, August 7, 2000 69
44. Dissolved Oxygen and Temperature Profiles, Little Chapman Lake, August 7, 2000 71
45. Carlson's Trophic State Index 80
46. Relative Abundance of Dominant Fish Species in the Chapman Lakes from 1964-1999 86
47. High Density and High Diversity Areas of Aquatic Vegetation in the Chapman Lakes 90
48. Areal Phosphorus Loading Rate for Big and Little Chapman Lakes 113
49. Target Areas for Management and Storm Drain Location Map 115
50. Land Within the Chapman Lakes Watershed Enrolled in the Conservation Reserve Program 117

TABLE OF TABLES

1. Chapman Lakes Watershed and Subwatershed Sizes....22
2. Monthly Rainfall Data for Year 2000 as Compared to Average Monthly Rainfall....26
3. Area Mapped in Highly Erodible and Potentially Highly Erodible Map Units by Subwatershed....30
4. Soil Types Adjacent to the Chapman Lakes....34
5. Land Use in the Chapman Lakes Watershed....38
6. Acreage and Classification of Wetland Habitat in the Chapman Lakes Watershed....39
7. Acreage of Wetland Habitat Loss in the Chapman Lakes Watershed....42
8. Chemical Characteristics of the Chapman Lakes' Inlet and Outlet Streams....47
9. Nutrient, Bacteria, and Sediment Concentration Data from the Chapman Lakes' Inlet and Outlet Streams....48
10. Nutrient and Sediment Loading Data from the Chapman Lakes' Inlet and Outlet Streams....48
11. Sediment, Nutrient, and Bacteria Load in Inlet Streams per Acre of Watershed....51
12. Morphological Characteristics of Big and Little Chapman Lakes....53
13. Selected Historical Data for Big Chapman Lake....57
14. Selected Historical Data for Little Chapman Lake....57
15. Results of the 1994 Lake Water Quality Assessment of Big Chapman Lake....62
16. Results of the 1998 Lake Water Quality Assessment of Big Chapman Lake....62
17. Water Quality Characteristics of Little Chapman Lake, 1989....63
18. Water Quality Characteristics of Little Chapman Lake, 1994....63
19. Water Quality Characteristics of Little Chapman Lake, 1998....64
20. Summary of Indiana Trophic State Index Scores for the Chapman Lakes....64
21. Water Quality Characteristics of Big Chapman Lake, 8/7/00....67
22. Plankton Species Composition in Big Chapman Lake, 8/7/00....68
23. Water Quality Characteristics of Little Chapman Lake, 8/7/00....69
24. Plankton Species Composition in Little Chapman Lake, 8/7/00....70
25. Mean Values of Some Water Quality Parameters and Their Relationship to Lake Production....74
26. Water Quality Characteristics of 355 Indiana Lakes Sampled from 1994 through 1998 by the Indiana Clean Lakes Program....75
27. The Indiana Trophic State Index....76
28. Common Herbicides and Their Effectiveness....100
29. Water Budget Calculations for Big Chapman Lake....107
30. Water Budget Calculations for Little Chapman Lake....108
31. Phosphorus Export Coefficients....109
32. Phosphorus Model Results for Big Chapman Lake....110
33. Phosphorus Model Results for Little Chapman Lake....111

TABLE OF APPENDICES

1. Chapman Lake Conservation Club Lake Resident Survey and Survey Instructions
2. Detailed Land Use by Subwatershed
3. Endangered, Threatened, and Rare Species List, Chapman Lakes Watershed
4. Endangered, Threatened, and Rare Species List, Kosciusko County
5. Historical Maps and Aerial Photographs Around Big and Little Chapman Lakes
6. Stream Sampling Laboratory Data Sheets
7. Historic Water Quality Parameters Including Volunteer Monitoring Data for Big Chapman Lake
8. Chapman Lakes Fish Species Lists
9. Chapman Lakes Macrophyte Species List
10. Additional Funding
11. Letter from Kosciusko County Soil and Water Conservation District re: Chapman Lakes Inlets
12. Sediment Survey Report

CHAPMAN LAKES DIAGNOSTIC STUDY
KOSCIUSKO COUNTY, INDIANA

INTRODUCTION

The Chapman Lakes lie in the Upper Tippecanoe watershed immediately northeast of Warsaw, Indiana (Figure 1). Specifically, the lakes are located in Sections 23, 24, 25, 26, and 35, Township 33 North, Range 6 East, in Kosciusko County. The lakes' watershed stretches out to the east, north, and west of the lakes, encompassing approximately 4,500 acres (1,822 ha) or 7 square miles (18 km^2). Water discharges through the lakes' outlet in the southwest corner of Little Chapman Lake to Heeter Ditch. Heeter Ditch is a tributary to Deeds Creek which flows into Pike Lake in Warsaw. From Pike Lake, water drains to the Tippecanoe River eventually reaching the Wabash River and being transported to the Ohio River in southwestern Indiana.

The Chapman Lakes and their watershed formed during the most recent glacial retreat of the Pleistocene era. The advance and retreat of the Saginaw Lobe of a later Wisconsian age glacier as well as the deposits left by the lobe shaped much of the landscape found in northeast Indiana (Homoya et al., 1985). In Kosciusko County, the receding glacier left a nearly level topography dotted with a network of lakes, wetlands and drainages.

The Chapman Lakes are located in the central portion of the Northern Lakes Natural Area (Homoya et al., 1985). The Northern Lakes Natural Area covers most of northeastern Indiana where the majority of the state's natural lakes are located. Natural communities found in the Northern Lakes Natural Area prior to European settlement included bogs, fens, marshes, prairies, sedge meadows, swamps, seep springs, lakes, and deciduous forests. Historically, much of the Barbee Lakes watershed was likely swamp habitat. Upland areas at the higher topographical elevations were likely forested with oak and hickory species. Some remnant representatives of these forests still exist in the Chapman Lakes watershed. Wetlands likely bordered the lakes with red and silver maple, American elm, and green and black ash being the dominant species in forested areas and cattails, swamp loosestrife, bulrush, marsh fern, and sedges being the dominant species in more open areas. The high quality wetland habitat adjacent to the Chapman Lakes exemplifies this native landscape.

Like much of the landscape in Kosciusko County, a large portion of the Chapman Lakes watershed was converted to agricultural land. Today, approximately 62% of the Chapman Lakes watershed is utilized for agricultural purposes (row crop and pasture). Property owners have developed much of the lake's northern, eastern, and southern shorelines.

Despite these changes in land use Big Chapman Lake has maintained fairly good water quality relative to many of the lakes in Kosciusko County. Studies on Big Chapman conducted over the past three decades confirm this. Some studies suggest water quality on Big Chapman may have improved slightly. Little Chapman Lake has not faired as well over the years. Historical studies show a decline in water quality from the early 1970's to today. The shallow basin morphology of Little Chapman Lake coupled with the lake's short residence time make it more sensitive to changes in its watershed.

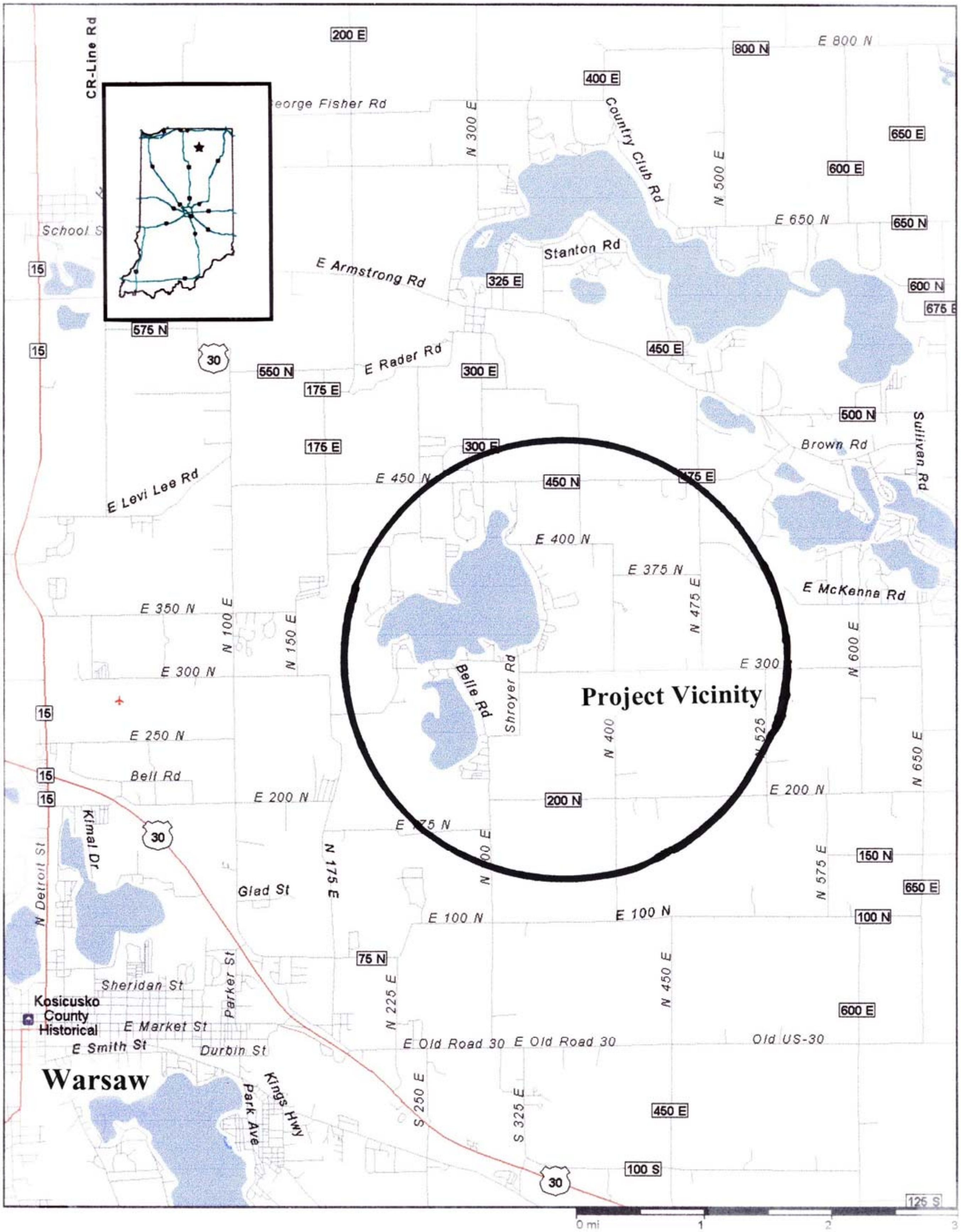


FIGURE 1. Location Map for the Chapman Lakes Diagnostic Study.

Source of Map: Streets Plus

Fortunately for both lakes, local property owners are committed to maintaining and improving water quality in the Chapman Lakes. The Chapman Lakes Conservation Club (CLCC) believes it is their responsibility to ensure clean, healthy lakes exist for their grandchildren's grandchildren. In an effort to achieve this goal, the CLCC applied for and received funding through the Indiana Department of Natural Resources Lake and River Enhancement Program for a lake and watershed diagnostic study. The purpose of the study is to describe the conditions and trends in Chapman Lakes as well as their watershed, identify potential problems, and make prioritized recommendations addressing these problems. The study included a review of historical studies including past fisheries reports, interviews with lake residents and state/local regulatory agencies, the collection of lake and stream water quality samples, an inventory of aquatic macrophytes and plankton, and field investigations identifying land use patterns. The CLCC assisted with the study by preparing and distributing a resident survey. This report documents the results of the study.

RESIDENT SURVEY

During the summer of 2000, the Chapman Lakes Conservation Club, Inc. (CLCC) conducted a resident survey. The club outlined three primary purposes of the survey: "1. To specifically identify, locate, and count every dwelling around the Chapman Lakes and (their) watershed; 2. Determine property types and uses; 3. Determine resident uses of the lakes and their view on specific issues" (Chapman Lakes Conservation Club, Inc., 2000). For reference, a blank survey along with the survey instructions for the survey task force team members is provided in Appendix 1. Although it is not stated as one of the club's goals, this data will also serve as a baseline level to monitor the perceived success of any lake restoration projects undertaken as a result of the recommendation in this diagnostic study.

Methods

The CLCC formed a survey task force to distribute the surveys to lake residents. To ensure accuracy and consistency, all survey task force volunteers followed the same protocol in conducting the survey. Between Memorial Day and Labor Day, task force volunteers went door-to-door around the lakes asking residents to respond to the survey. The summer time frame was chosen to correspond with the peak resident occupancy season at the lakes. A task force volunteer stayed at the respondent's residence, filling in the resident's response to each question on the survey. No surveys were left with residents to complete on their own. This allowed task force volunteers to provide clarification on any of the survey questions, if necessary.

Attempts were made to survey every residence around the lakes. Two hundred forty-two surveys were completed. Six surveys were also collected that noted the resident refused to cooperate in completing the survey. Despite not being able to perform a survey at each residence in the watershed, all residential areas around the lakes were represented by the survey (Figure 2). Based on this roughly even geographical distribution, the subset of surveys collected is assumed to accurately represent the views and opinions of the entire lake community. The following graph (Figure 3) shows the number of completed surveys by region of the lake.

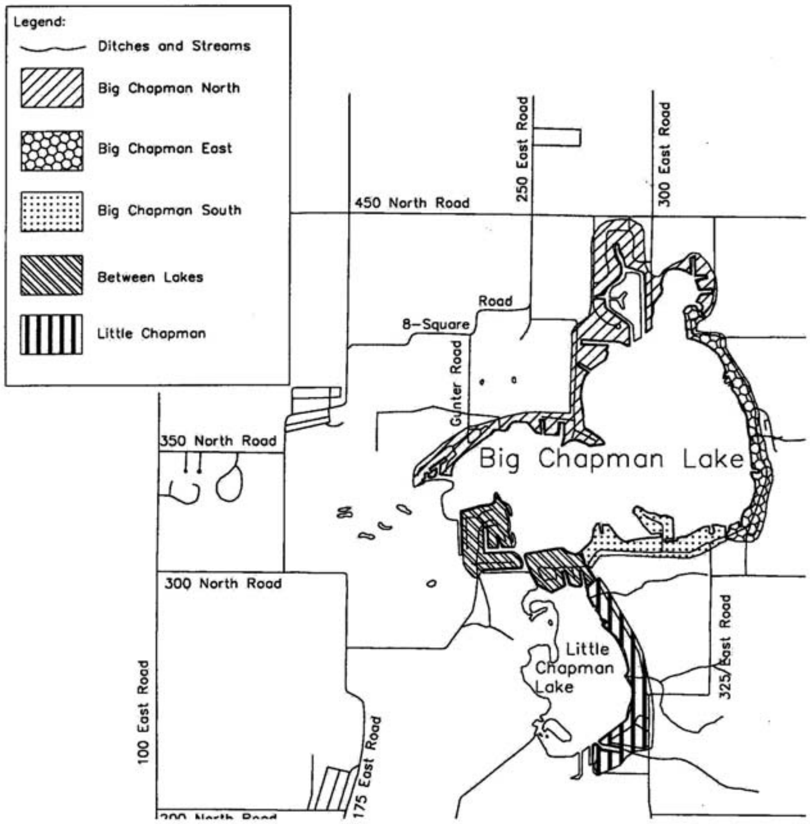


FIGURE 2. Residential areas or zones covered by the 2000 lake resident survey of the Chapman Lakes.

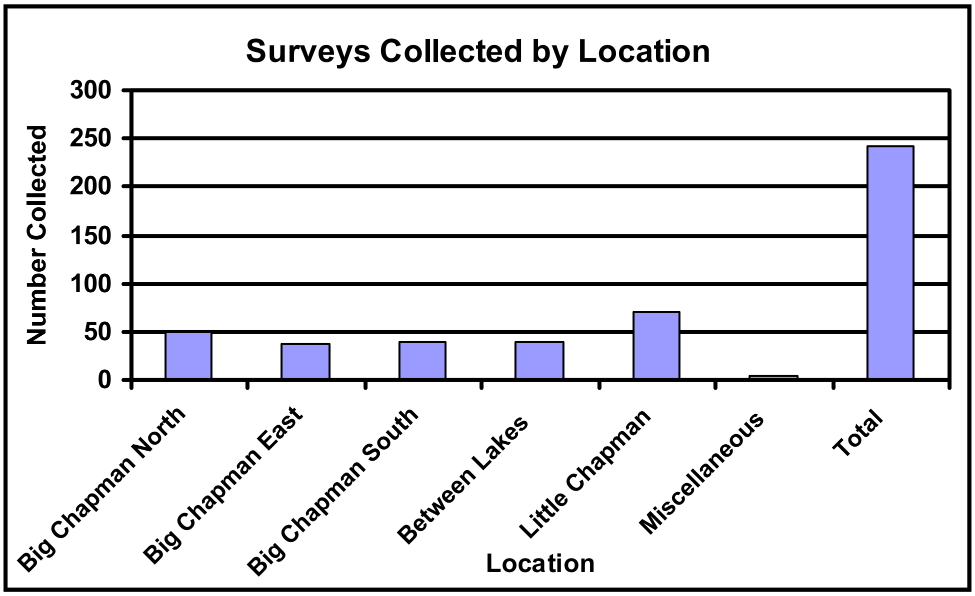


FIGURE 3. Number of surveys collected for general locations around the Chapman Lakes. Big Chapman North encompasses the area from Island Park to the mobile home park on the northeast corner of the lake. Big Chapman East extends from the Chapman Lake District to the public access site. Big Chapman South covers the area west of the public access site to Arrowhead Park. Between Lakes includes Osborne Landing and the area east of the channel between the lakes. Little Chapman encompasses all houses from the northeastern corner of Little Chapman Lake to the lake's southern tip.

Results

The survey contained a variety of questions about the characteristics of the residences surrounding the lakes. At the time of the survey, most respondents (93%) were owners. The length of property ownership varied. Thirty-two percent of the respondents had owned their property for more than 20 years. Twenty percent had owned the property for 5 to 10 years. Nearly 15% were new owners, having owned the property for less than three years. Most (63%) residents lived at Chapman Lakes year round. Twenty percent of the respondents reported occupying their Chapman Lake residence only during the summer. Almost 10% lived at the lakes on weekends only (Figure 4).

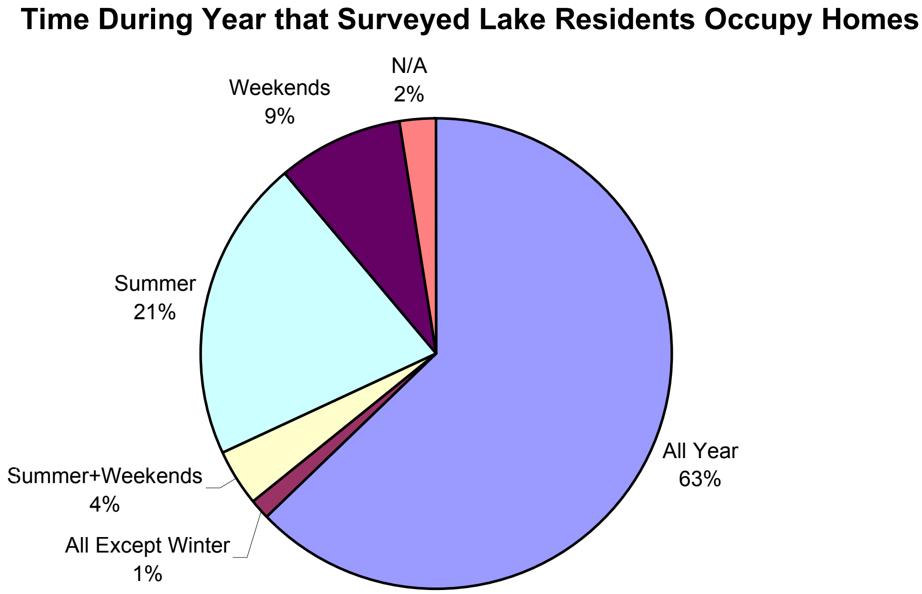


FIGURE 4. Time during year that surveyed lake residents occupy homes expressed as a total of the residents surveyed. An answer of N/A means that the resident answering the question either could not determine or felt that the question was inapplicable.

In terms of type of residence, most respondents (79%) reported owning a single-family residence, while 14% reported owning cottages (Figure 5). More than 80% of the residences were over 20 years old. Sixty-two percent of the residences were over 30 years old. Almost 10% of the residences were less than 10 years old (Figure 6). Most of the cottage and mobile homes were over 20 years old (91% and 83% respectively).

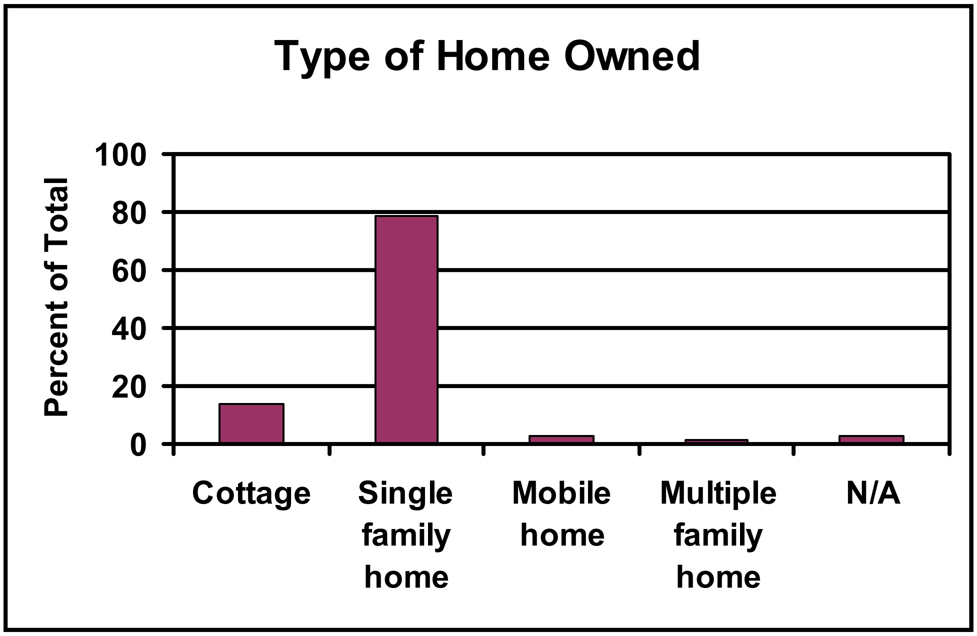


FIGURE 5. Types of homes owned by survey respondents around the Chapman Lakes expressed as a percent of the total surveyed.

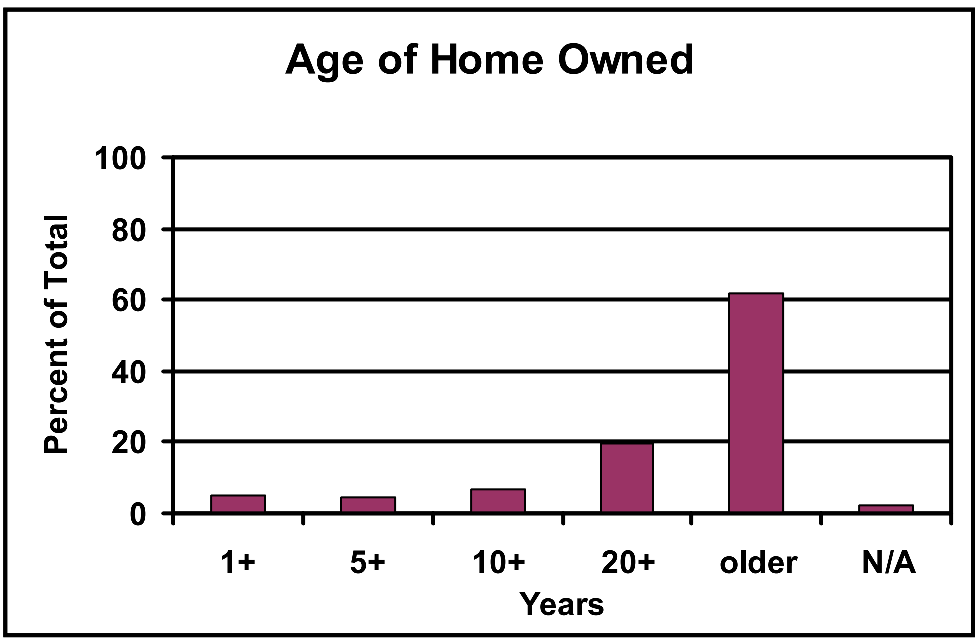


FIGURE 6. Ages of homes owned by survey respondents around the Chapman Lakes regardless of home type expressed as a percent of the total surveyed.

The survey asked lake residents to record the number of bedrooms and baths in their homes to serve as a proxy for home size. Forty-four percent of the respondents reported having two bedrooms in their residence. Thirty-eight percent noted having three bedroom homes. Almost nine percent reported having four or more bedrooms in their residence. Most respondents reported either one or two bathrooms in their residences (47.5% and 33% respectively). Just over 5% of the respondents recorded having four or more bathrooms in their homes.

Septic age mirrored residence age to some extent (Figure 7). Forty-three percent of the respondents reported septic systems older than 15 years. Only 14% of the homes had new (less than 5 years old) septic systems. Mound systems serviced 19% of the homes around the lakes. Most of the mound systems were relatively new; 77% were less than 10 years old. Some (39%) new homeowners (1+ years) reported having septic systems older than 5 years old. This suggests that new homes were built to replace older homes or cottages, but these homes still utilize the old septic systems. Conversely, not all of the older homes were equipped with older septic systems. Forty-eight percent of the homes in the 20+ age range had septic systems that are less than 15 years old. Similarly, 37% of the respondents from homes that fell in the "older" category reported having septic systems that were less than 15 years old.

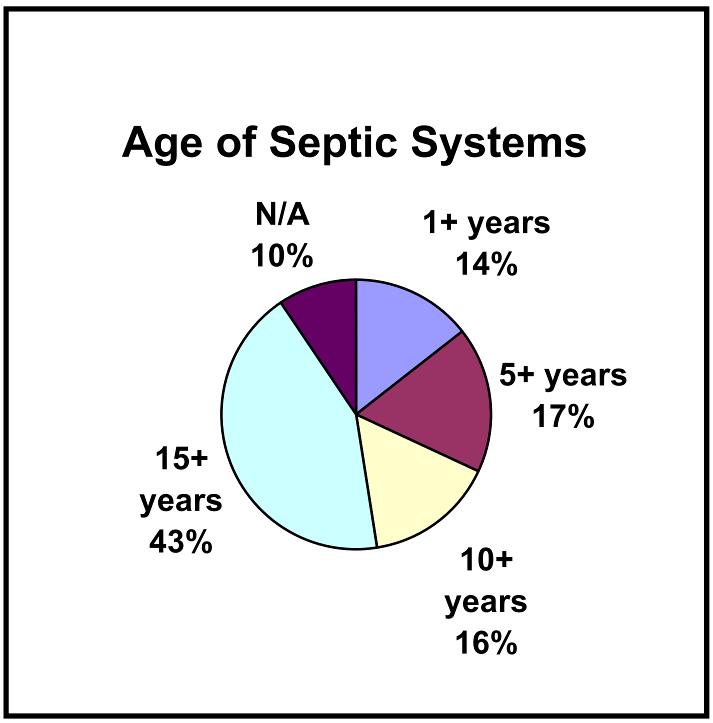


FIGURE 7. Age of septic systems owned by surveyed lake residents around the Chapman Lakes expressed as a percentage of the total surveyed.

Lake residents also recorded information about the interior and exterior features of their homes that may impact their lakes' health. Sixty-seven percent of the respondents' homes were equipped with washing machines, while 23% had garbage disposals. Twenty three percent of the respondents reported having rain gutters that drain directly to the lake. Just over 1% of the respondents claimed to have garage drains discharging to the lakes. No one reported having washer drains discharging directly to the lakes. Several individuals noted the presence of other drains including well or spring drains, miscellaneous surface drains, and sump pump drains. Thirteen percent of respondents reported having a natural shoreline. In contrast, over 78% had some type of seawall lining their shore.

Lake Use

To better understand the recreational pressure on the lakes, the survey contained several questions regarding resident use of the lakes and the frequency of use. As shown in Figure 8, most respondents (56%) used the lakes one to four times a week. Fewer than 2% of the respondents used the lake only occasionally. Twenty percent of respondents reported using the lake only on the weekends. When asked whether lake use has increased or decreased, nearly 80% of respondents perceived an increase in lake usage; only 2.5% of respondents saw a decrease in lake usage. (The remainder saw no change in lake usage or did not answer the question.)

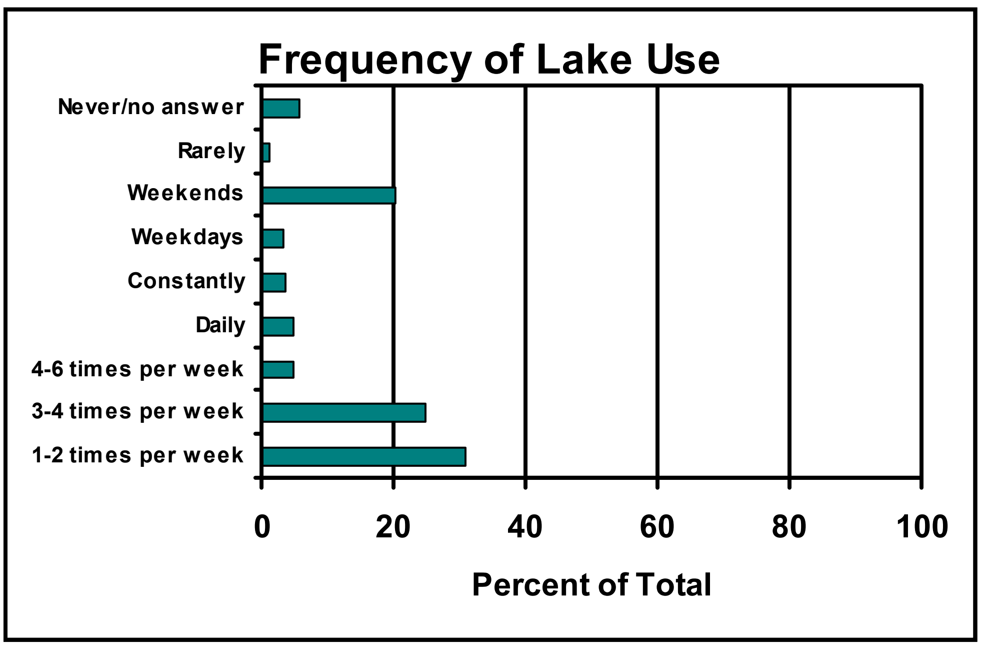


FIGURE 8. Frequency with which the Chapman Lakes are used by surveyed lake residents expressed as a percentage of total surveyed.

Figure 9 illustrates the variety of activities respondents enjoyed on the lakes. Seventy-one percent of respondents fished in the lakes. Swimming was another popular use with seventy-four percent of respondents reporting that they engaged in this activity. Forty-seven percent of respondents picnicked on the lakes. Forty-four percent of respondents power boated on the lakes. A minority of respondents (20%) used personal watercraft on the lakes. Sailing and SCUBA diving were less popular activities; only 7% and less than one percent of the respondents, respectively, participated in these activities.

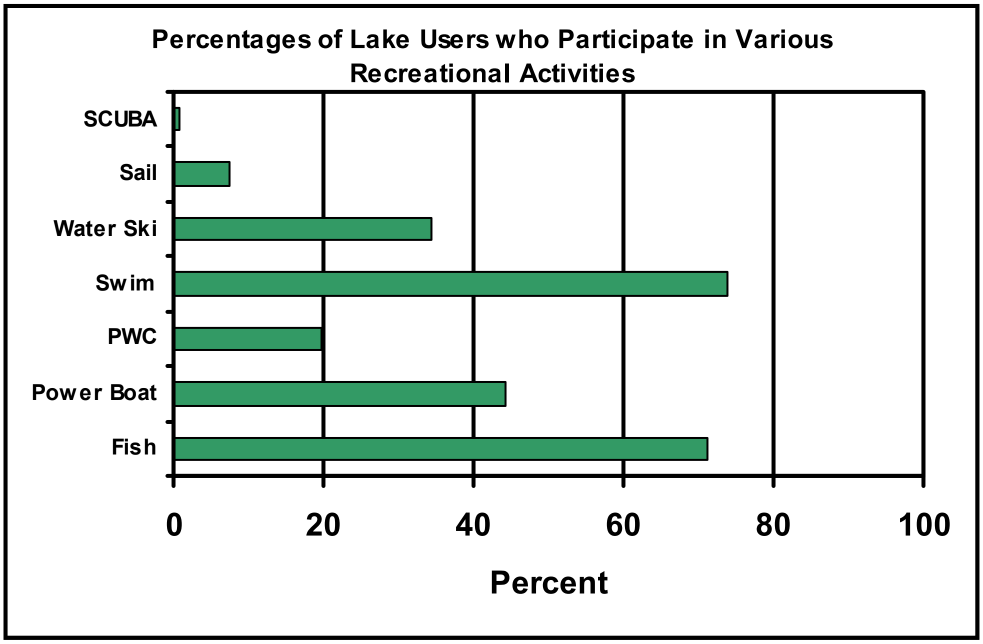


FIGURE 9. Percentages of surveyed lake users who participate in various recreational activities on the Chapman Lakes. PWC refers to the use of personal watercraft such as jet skis, etc.

The Chapman Lakes residents own many different types of boats (Figure 10). Pontoon boats were the most popular with 58% of the respondents owning this type of boat. Almost one in every three respondents owned a ski boat. A similar percentage owned row boats. Canoes and sailboats were less popular with only 7% and 10% of the respondents, respectively, owning these types of boats. Many respondents (67%) owned more than one type of boat (Figure 11). Over ten percent of the respondents owned four or more types of boats. (It is important to note that the survey only asked respondents about the *type* of boat owned. For example, if a resident owned two ski boats, he or she would only own one type of boat.)

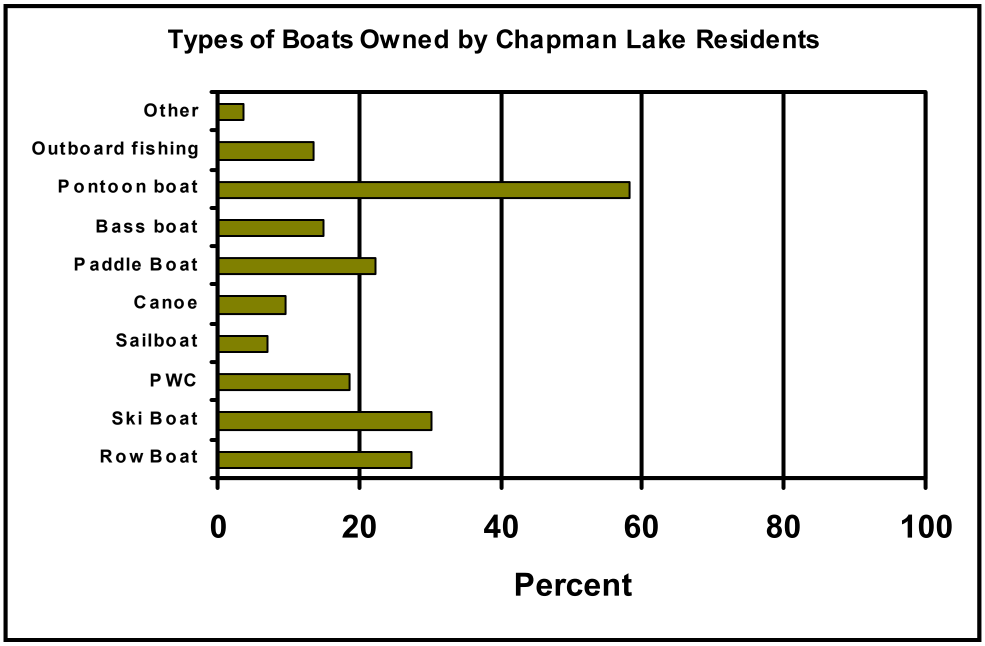


FIGURE 10. Percentages of surveyed lake residents owning different types of boats and personal watercraft (PWC).

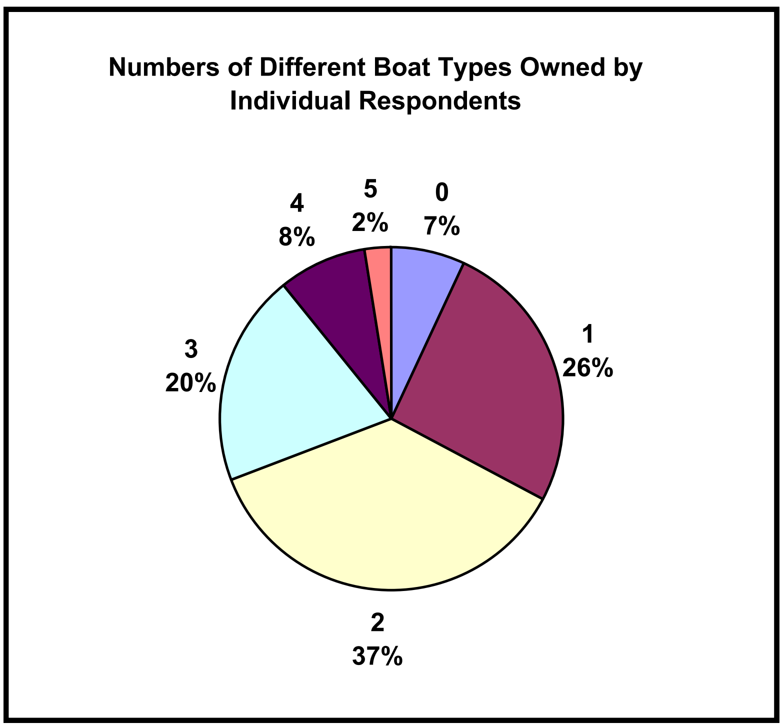


FIGURE 11. Percentage of surveyed lake residents owning between zero and five different boat types.

Residents' Perceptions of the Lakes

Lake residents were asked about water clarity and fishing quality of the two lakes. Forty-six percent of the respondents believed water clarity was worse at the time of the survey than it had been in the past. Only fifteen percent felt water clarity was better at the time of the survey than it had been in the past. (Nearly forty percent of the respondents chose not to answer this question or their answers could not be determined.) Lake residents were also encouraged to note when water clarity was better or worse. Of those responding that water clarity was worse at the time of the survey, approximately 65% believed it was worse during the survey period than it was 5 or 10 years ago (Figure 12). Those who believed water clarity was better at the time of the survey were most likely comparing it to recent years. As illustrated in Figure 13, over 60% of those who believed that water clarity was better at the time of the survey compared the conditions to those in the past 10 years. Respondents were allowed to state that the water clarity was both better and worse as long as they noted a time frame with each. For example, a respondent could write that water clarity was worse at the time of the survey than it was last year, but better than it was 15 years ago. Fewer than ten respondents elected to answer the question in this manner. Because of this small sample size, their responses are not reported here.

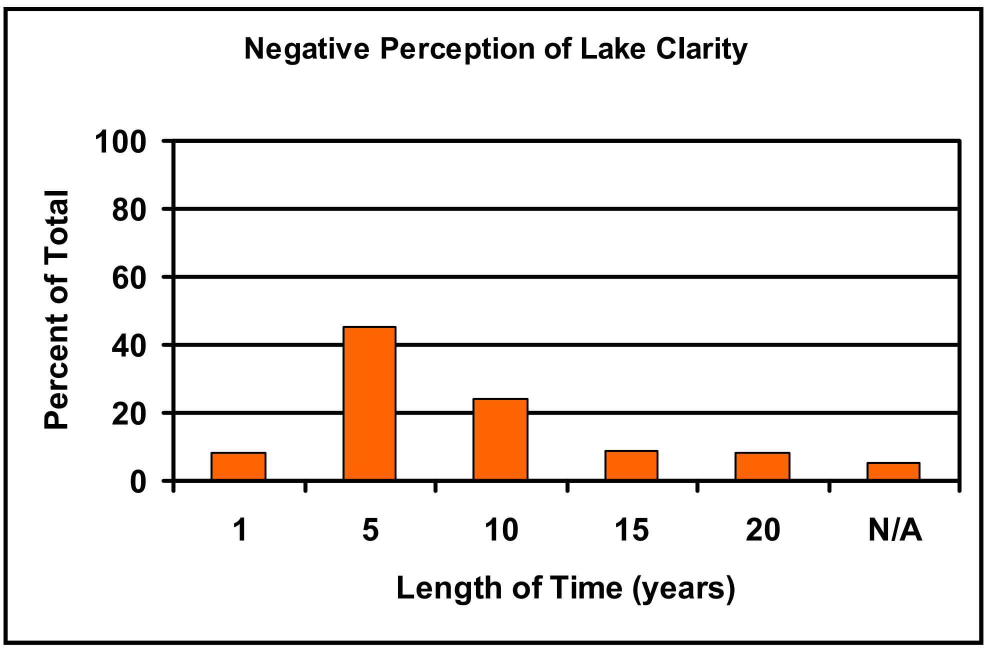


FIGURE 12. Length of time over which responding lake residents perceive that water clarity in the Chapman Lakes has been deteriorating. For example, 45% of lake residents responding that lake clarity is poorer believe it to be worse now than it was five years ago.

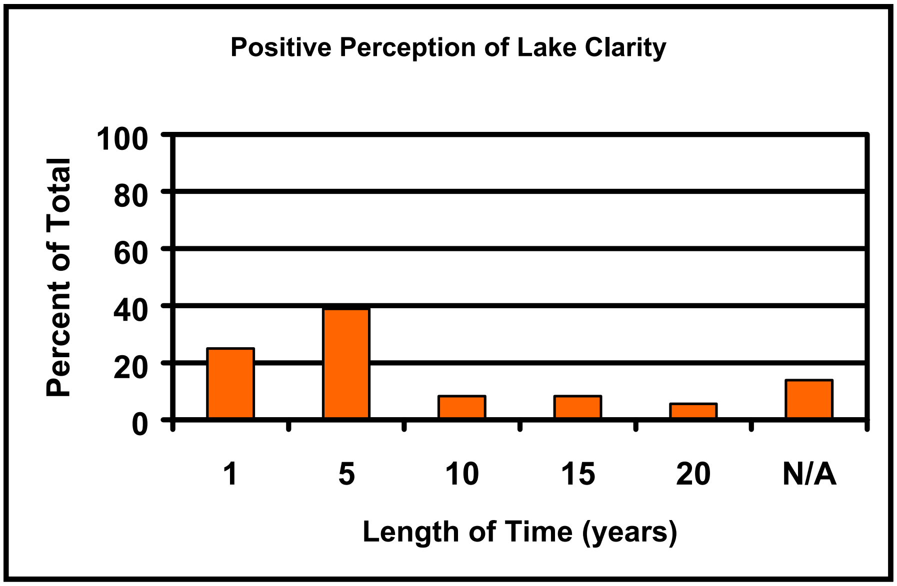


FIGURE 13. Length of time over which responding lake residents perceive that water clarity in the Chapman Lakes has been improving. For example, 25% of lake residents responding that lake clarity is improved believe it to be better now than it was one year ago.

The survey was analyzed to reveal any correlations between use of the lake or length of residence on the lake and the perception of water clarity. No difference in the perception of the lakes' water clarity was found between residents who reported using the lake only once or twice a week and those who reported using the lake three or more times a week. Those who fished on the lakes report similar perceptions of water clarity compared to the entire lake population. Those who swam in the lake were slightly more likely to perceive better water clarity compared to the lake population as a whole. Residents who had owned property for ten or more years were more likely to perceive the lakes' water clarity as worse than new residents who had lived on the lake for fewer than ten years. It is also interesting to note that longtime residents were more likely to answer the question than newer property owners.

The survey recorded residents' perception of the fishery as well. Thirteen percent of the respondents felt fishing was better at the time of the survey than it was in the past; 38% believed fishing was worse at the time of the survey than it was in the past, while nearly 49% of the respondents did not answer the question. (Most people who responded to this question also stated that they fished on the lakes when asked about lake usage. But a few of the respondents did not appear to fish on the lakes.) When asked to place their response in a time frame, most respondents who felt the fishery was better at the time of the survey compared to past years believed the improvement occurred over the past one to five years (Figure 14). Most respondents who felt the fishery was worse at the time of the survey were comparing the fishery to the one present five or ten years ago (Figure 15).

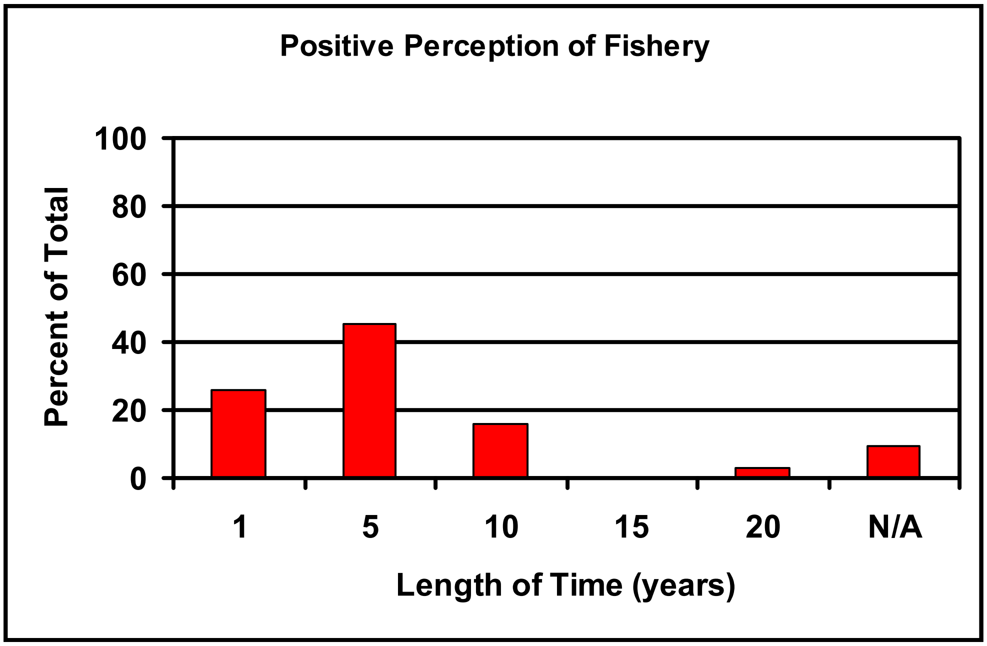


FIGURE 14. Length of time over which responding lake residents perceive that the Chapman Lakes' fishery has been improving. For example, 45% of the lake residents responding that the fishery is improved believe it to be better now than it was five years ago.

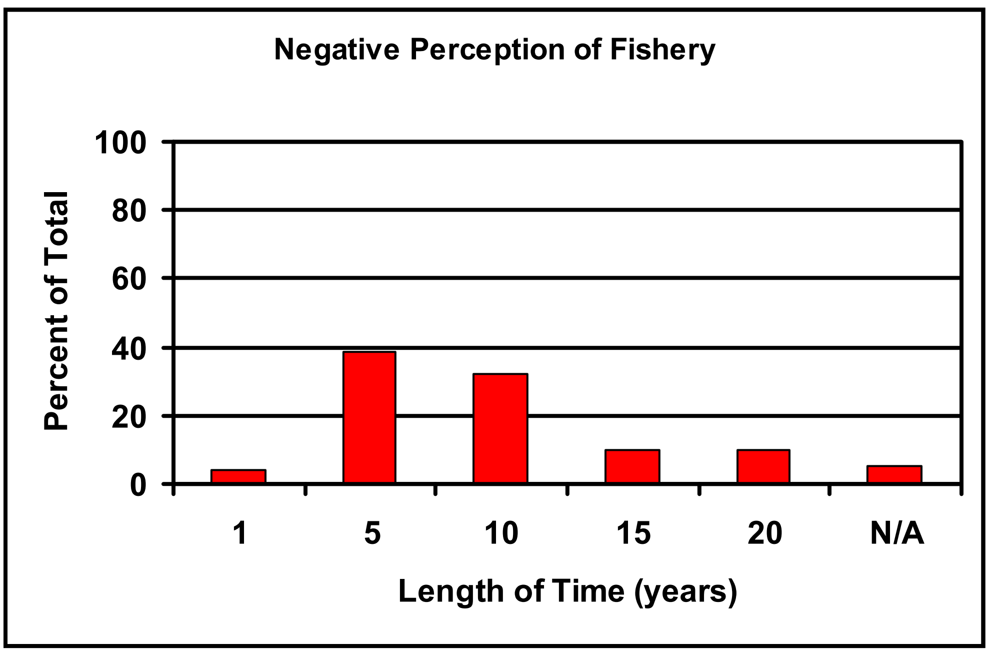


FIGURE 15. Length of time over which responding lake residents perceive that the Chapman Lakes' fishery has been deteriorating. For example, 39% of the lake residents responding that the fishery is poorer believe it to be worse now than it was five years ago.

Because Big and Little Chapman offer different fisheries, the survey was analyzed to determine if residents on the two lakes had differing perspectives of the fisheries. No difference was found except that Little Chapman Lake residents were more likely to answer the question than Big Chapman Lake residents. Correlations between length of residence on the lakes/usage of the lakes and perception of the fishery were also examined. Respondents who had lived on the lake more than ten years were more likely to feel the fishery was worse at the time of the survey than in the past compared to newer respondents (i.e., those who had lived there fewer than 10 years). In addition, residents who spent less time on the lakes (fewer than three times a week) were more likely to view the fishery as better at the time of the survey than it was in the past compared to those residents who spent a greater amount of time on the lakes (three or more times a week).

Specific Problems

Residents were asked to note specific problems in their area of the lake. Figure 16 shows the percentage of respondents reporting the incidence of high water, storm water runoff, ditch overflow, sediment accumulation, and plant accumulation in their area of the lake. Sixty-five percent of respondents observed an accumulation of aquatic plants near their property. Nearly 40% reported sediment accumulation in the lake near their property. Fewer respondents recorded an incidence of high water or ditch overflow on their property (10% and 6%, respectively). Fifteen percent of the residents responding to the survey did not observe any change in the area of lake immediately adjacent to their property. (This only includes the percentage of respondents who marked "No Change". It does not include respondents who did not answer any part of this section.)

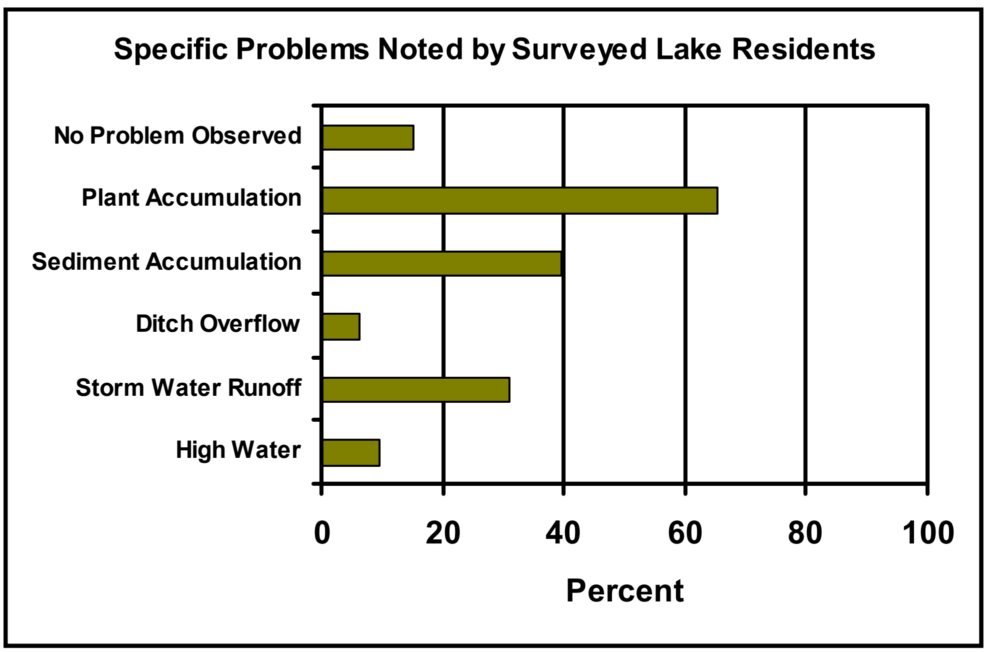


FIGURE 16. Percentage of respondents reporting the incidence of high water, storm water runoff, ditch overflow, sediment accumulation, and plant accumulation in their area of the lake. Some surveys recorded no problems.

To provide additional information on the subject, residents were asked to estimate the frequency of incidence of these specific problems. Forty percent of those reporting storm water runoff on their property stated that this problem happened more than twice a year. Another ten percent estimated that the problem occurred once or twice a year. Thirty percent did not report a frequency of incidence. Of those reporting sediment accumulation in the lake in front of their property, most (63%) observed this over the past ten years (Figure 17). Similarly, 67% of those noting plant accumulation in front of their property estimated that the accumulation started in the past ten years (Figure 18).

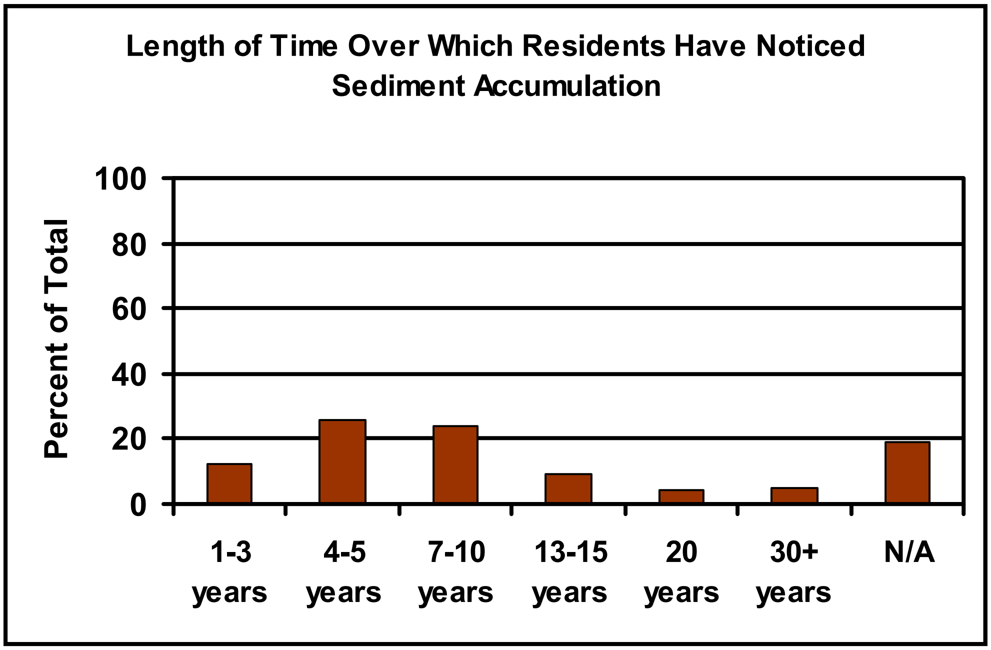


FIGURE 17. Length of time over which responding lake residents have noticed sediment accumulation in their area of the lake. For example, 26% of the residents responding to sediment accumulation problems have been noticing the accumulation within the past 4-5 years.

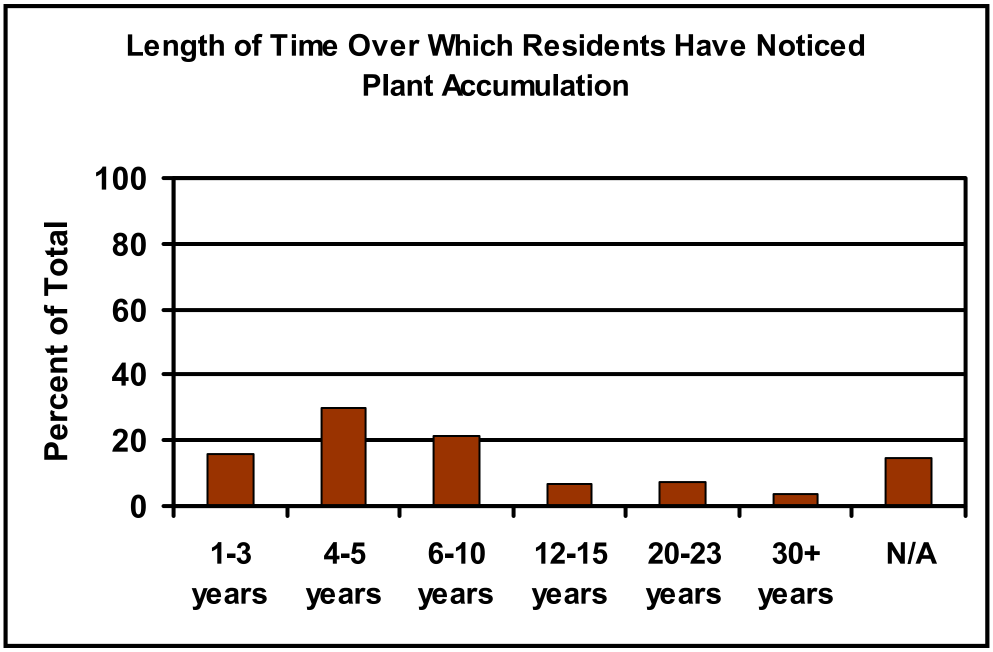


FIGURE 18. Length of time over which responding lake residents have noticed plant accumulation in their area of the lake. For example, 30% of the residents responding to plant accumulation problems have been noticing the accumulation within the past 4-5 years.

The survey was analyzed to explore any correlations between the specific location on the lakes and the problems reported. No correlations were found. The problems appeared to be spread throughout the lakes. The survey was broadly analyzed to examine any differences between the lakes as well. Similar results were obtained. Those who lived on Big Chapman Lake were equally as likely to report plant or sediment accumulation as those who lived on Little Chapman Lake. Those living on Little Chapman Lake reported a slightly higher incidence of storm water runoff on their property than those on Big Chapman Lake. This was the only localized effect revealed by the analysis.

The survey provided two opportunities for residents to state the lakes' biggest problems. One opportunity offered four problems and asked residents to check the one that was the biggest problem. Figure 19 shows the results of this question. (It is important to note that respondents often checked more than one problem.) Of these four specific problems, most respondents (67%) felt rooted aquatic plants are the lakes' biggest problem. Thirty-five percent of the respondents felt the boat population is the lakes' biggest problem. Smaller percentages of respondents saw runoff and zebras mussels as the biggest problem (26% and 28%, respectively).

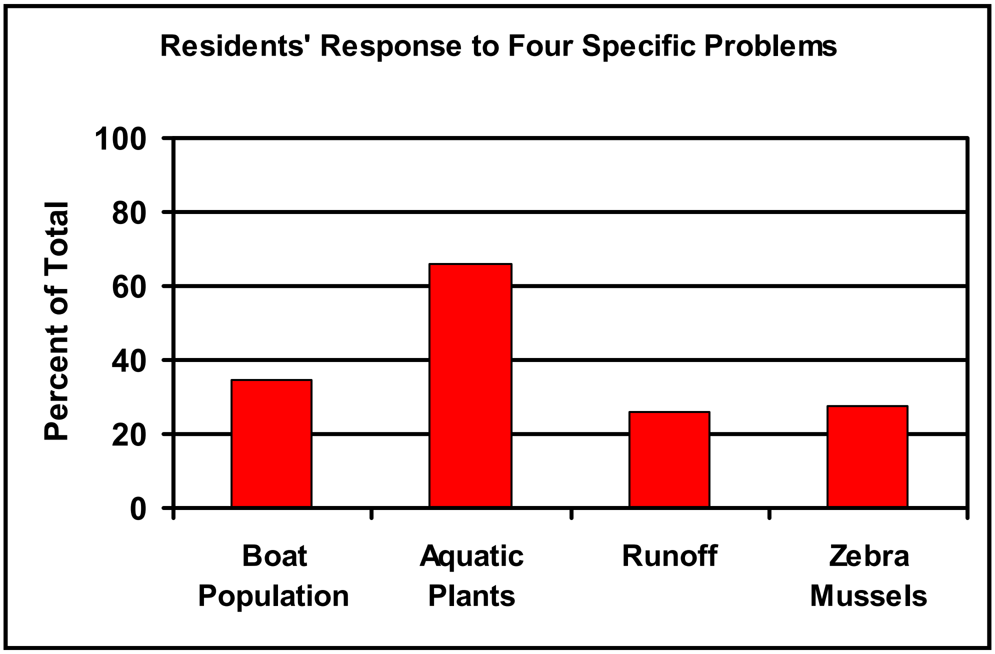


FIGURE 19. Percentage of surveyed lake residents responding to one of four specific issues as the biggest problem at the Chapman Lakes.

When asked the question of what bothered residents the most about the lakes in an open-ended format, almost 40% of respondents listed boating issues (boat speed, boat traffic/population, lack of observation of boating laws, boat noise) as the biggest problem on the lakes (Figure 20). Personal watercraft (PWC) and aquatic plants ranked behind boating issues with 31% and 30% of the respondents reporting these as bothersome on the lakes. Sediment accumulation/runoff, septic systems (and lack of sewers), trash, and water quality were the next most common answers. Again, respondents often listed more than one answer to this question.

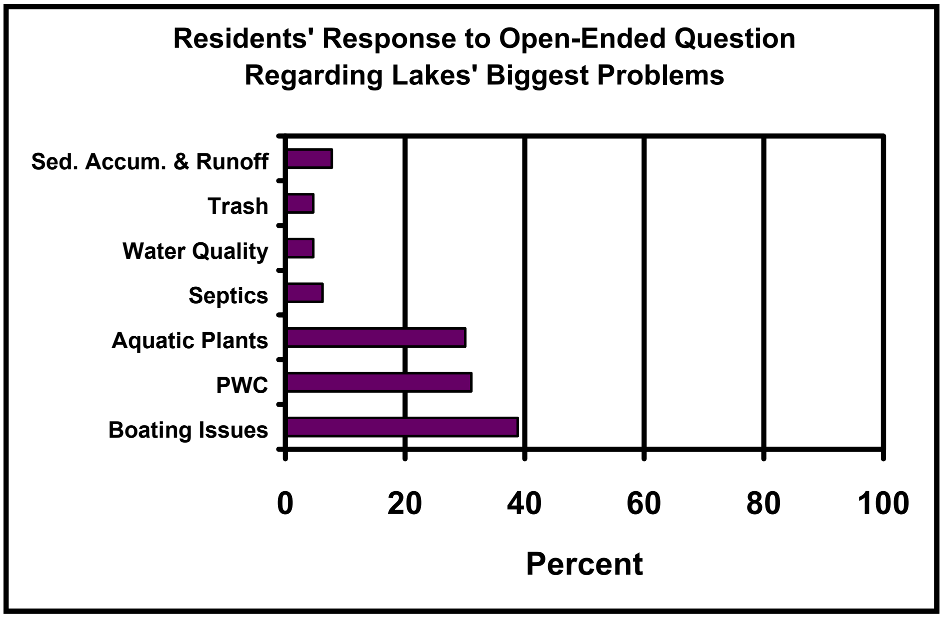


FIGURE 20. Response of surveyed residents to an open-ended question regarding the lakes' biggest problems. Personal watercraft is abbreviated PWC.

The Good Qualities

When asked what they liked most at the lake in an open-ended format, most residents (65%) listed aesthetic qualities of the lake (scenic view, peace and quiet, relaxing atmosphere, etc.). The lakes' water quality and fishery were also popular among respondents, with 16% and 12% recording these as the features they liked best about the lake. Smaller percentages of respondents reported liking the wetlands, their neighbors, the small size of the lakes, and "everything" about the lakes (Figure 21).

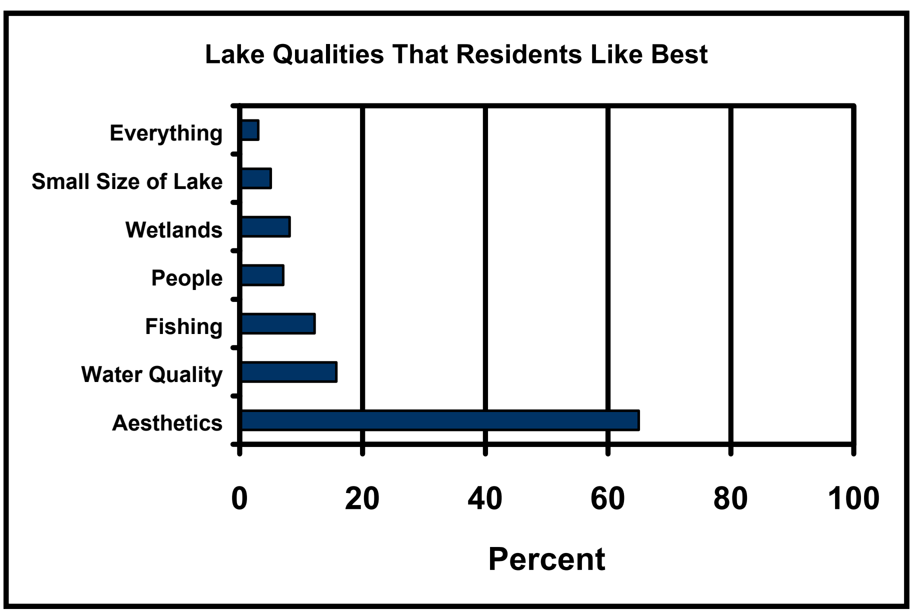


FIGURE 21. Best-liked qualities of the Chapman Lakes expressed as a percent of the total surveyed.

Discussion

While the survey provides excellent information on many characteristics of the lakes and their uses, this discussion will concentrate on lake usage. The other portions of the survey will be addressed in more appropriate sections. (i.e., Lake residents' perception of rooted plants in the lake will be discussed in the macrophyte survey section.)

As the results from the survey indicate, the Chapman Lakes receive heavy use. More than 50% of the respondents reported being out on the lakes 1-4 times per week. Others noted that they are on the lakes "constantly" or on a daily basis. The number of boats owned by residents supports this high usage. Over 80% of the survey respondents reported owning at least one type of boat, and over two thirds of the respondents reported owning two or more types of boats. The residents themselves perceive an increase in the lake usage; nearly 80% of the respondents to the survey observed an increase in lake usage.

While some uses of the lakes have little impact on the lakes, others affect it in more significant ways. Motorized boating is of particular concern on lakes. Several studies have outlined the negative impacts motorized boats have on a lake ecosystem (Yousef et al., 1978, Asplund, 1996, Wagner, 1991). These impacts include damage to rooted plant beds. Rooted plants, particularly native emergents, play an important role in a lake system. These plants filter runoff water, uptake nutrients preventing the uptake by nuisance algae, and provide fish and wildlife habitat. Destruction of rooted plants by motor boat propellers reduces the plant community's ability to provide these functions.

Motor boats also facilitate the spread of exotic species that can reproduce from a fragment of the plant. Eurasian water milfoil is capable of this mode of reproduction. Fragments cut from one plant can grow roots and become a new individual plant. This often increases the density of the species in that location. In addition, propellers can spread the plant throughout the lake by transporting cut fragments from a location of heavy density to one where it has not established itself. This is of particular concern on Big Chapman Lake where nuisance populations of Eurasian water milfoil are confined to certain areas of the lake. Boats that are not carefully cleaned after use can even spread Eurasian water milfoil from one lake to another. (This also occurs with zebra mussels and is the main method of distribution by both species.)

Other negative impacts include the resuspension of bottom sediments. This has the potential to increase nutrient availability to algae thereby promoting nuisance blooms. The resuspension of bottom sediments also increases the turbidity of the lake. Increased turbidity takes away from the aesthetic pleasures of a lake, can affect fish spawning, and may even be responsible for a decrease in property values. Few people enjoy a lake with poor water clarity.

Motorized boats can also pollute the water and air. While not common, gasoline and oils spills can occur during boating activities or, more commonly, during refueling activities. Because they do not face the same regulations as cars, boat motors often contribute relatively more to air pollution than car motors. Older motors spew several times the air pollution generated by newer motors. Depending upon the size of motor and how it is used, noise pollution is another problem encountered on many lakes. This is of particular concern with personal watercraft. Considering the vast majority of survey respondents who noted that they most enjoyed the aesthetics features of the lakes, these types of pollution can pose a serious conflict of use.

While motorized boating activities may have a greater potential to negatively impact a lake's health compared to more passive or human powered activities, it is important to note that lake communities can take steps to reduce any negative impacts. A strong, enforceable lake use management plan would reduce many of the impacts outlined above. The plan would recognize that residents use the lake for a variety of activities and that sometimes these activities are in conflict with one another. A good plan would strive to balance motorized boaters' rights and desires with those of other users.

The resident survey provides a good start toward identifying the residents' preferred uses and could help guide the development of a lake use management plan. The survey indicates that more people swim and fish than participate in motorized boating activities. A management plan might include the development or expansion of no-wake zones to protect swimmers and anglers. Conservation or limited-use areas could be set aside to protect special spawning areas or important macrophyte beds. Specific time frames for certain activities could be established. The survey indicates that residents most enjoy the aesthetic aspects of the lakes, while relatively few use personal watercraft. Based on this preference, use of personal watercraft may be prohibited during early morning hours or in the evening to allow for fishing or quiet enjoyment of the lake. On lakes as large as Big and Little Chapman, establishment of different zones for different use may be a possibility as well.

Those listed above are just a few of the options available to manage lake use. Regardless of the specifics of the plan, the best plan is one that is developed by the entire lake community and has taken into account everyone's opinion. This includes non-resident lake users as well. Future surveys could poll non-resident lake users to obtain more accurate estimates of the boating pressure and use of the Chapman Lakes. Non-resident lake users should also be given the opportunity to voice opinions during the development of any lake recreational management plan. People are more likely to comply with plans they helped establish.

Recreational management plans on public lakes are often voluntary in nature, and therefore difficult to enforce. Recent legislative changes make it possible to create minimal use zones for the protection of the lakes' biological community. Use regulations in these zones would be enforced by the Indiana Department of Natural Resources. Lake residents should contact the IDNR to determine the new law's applicability to the Chapman Lakes. At a minimum, lake residents might solicit the assistance of IDNR Conservation Officers in the enforcement of existing regulations.

WATERSHED PHYSICAL CHARACTERISTICS

Figure 22 is the United States Geological Survey topographical map for the Chapman Lakes area. The thin line of the map highlights the limits of the Chapman Lakes watershed. The watershed encompasses approximately 4,500 acres or 7 square miles (1,822 ha or 18 square km). The topography of the Chapman Lakes watershed is typical of much of Kosciusko County. Land to the east of the lakes exhibits a gently rolling topography. Relief ranges from approximately 940 feet above MSL at the highest point in the watershed to approximately 828 feet at the lakes. Land to the west of the lakes is flatter than the land to the east of the lakes with large wetland expanses lying adjacent to the lakes.

Table 1 presents the physical characteristics of the Chapman Lakes watershed and its subwatersheds. Four main drainages transport runoff water from the watershed to the Chapman Lakes. Big Chapman Lake has one main inlet: Crooked Creek. Crooked Creek drains approximately 775 acres (314 ha). Little Chapman Lake has three primary drainages: the Arrowhead Park drainage, the Highlands Park drainage, and Lozier's Creek. Lozier's Creek is the largest of the three, draining approximately 839 acres (340 ha). The Arrowhead Park drainage and the Highlands Park drainage drain approximately 303 and 122 acres (123 and 49 ha), respectively. Approximately 2528 acres (1,023 ha) of land drain directly to the lakes or through minor drainages before entering the lakes. Figure 23 shows each subwatershed's coverage. In total, the Chapman Lakes possess a watershed area to lake area ratio of approximately 7.6:1.

TABLE 1: Chapman Lakes Watershed and Subwatershed Sizes.

	Area (acres)	**Area (hectares)**	**Percent of watershed**
Subwatershed			
Crooked Creek	775	313.8	17.0%
Lozier's Creek	839	339.7	18.4%
Arrowhead Park Drainage	303	122.7	6.6%
Highlands Park Drainage	122	49.4	2.7%
Area adjacent to lake	2528	1023.5	55.4%
Total watershed	4567	1849.0	100%
Watershed to Lake Area Ratio	**7.6:1**		

Watershed size and watershed to lake area ratios can affect the chemical and biological characteristics of a lake. For example, lakes with large watersheds have the potential to receive greater quantities of pollutants (sediments, nutrients, pesticides, etc.) from runoff than lakes with smaller watersheds. For lakes with large watershed to lake ratios, watershed activities can potentially exert a greater influence on the health of the lake than lakes possessing small watershed to lake ratios. Conversely, for lakes with small watershed to lake ratios, shoreline activities may have a greater influence on the lake's health than lakes with large watershed to lake ratios.

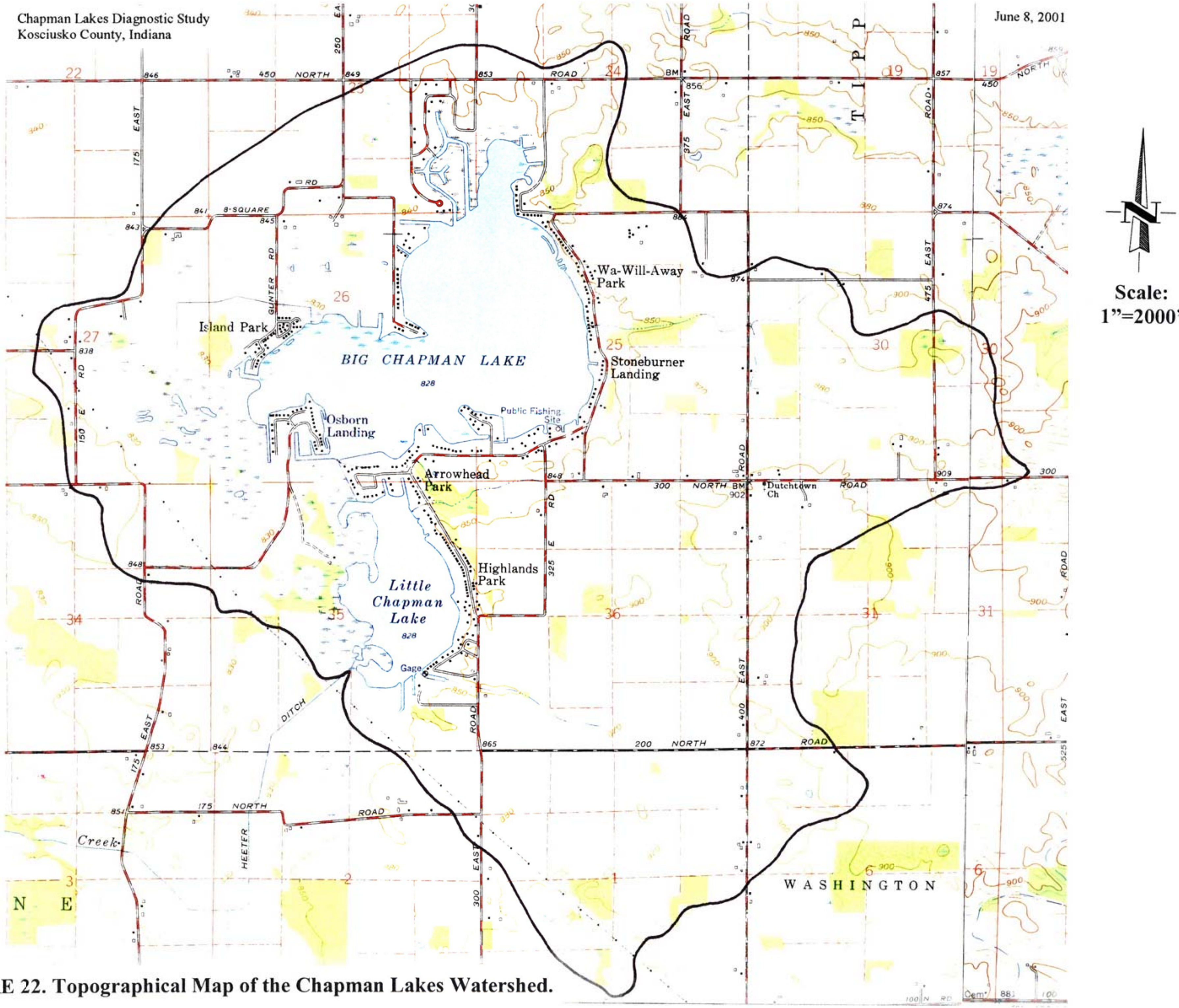


FIGURE 22. Topographical Map of the Chapman Lakes Watershed.

Source of Map: U.S.G.S. 7.5 Minute Topographical Map

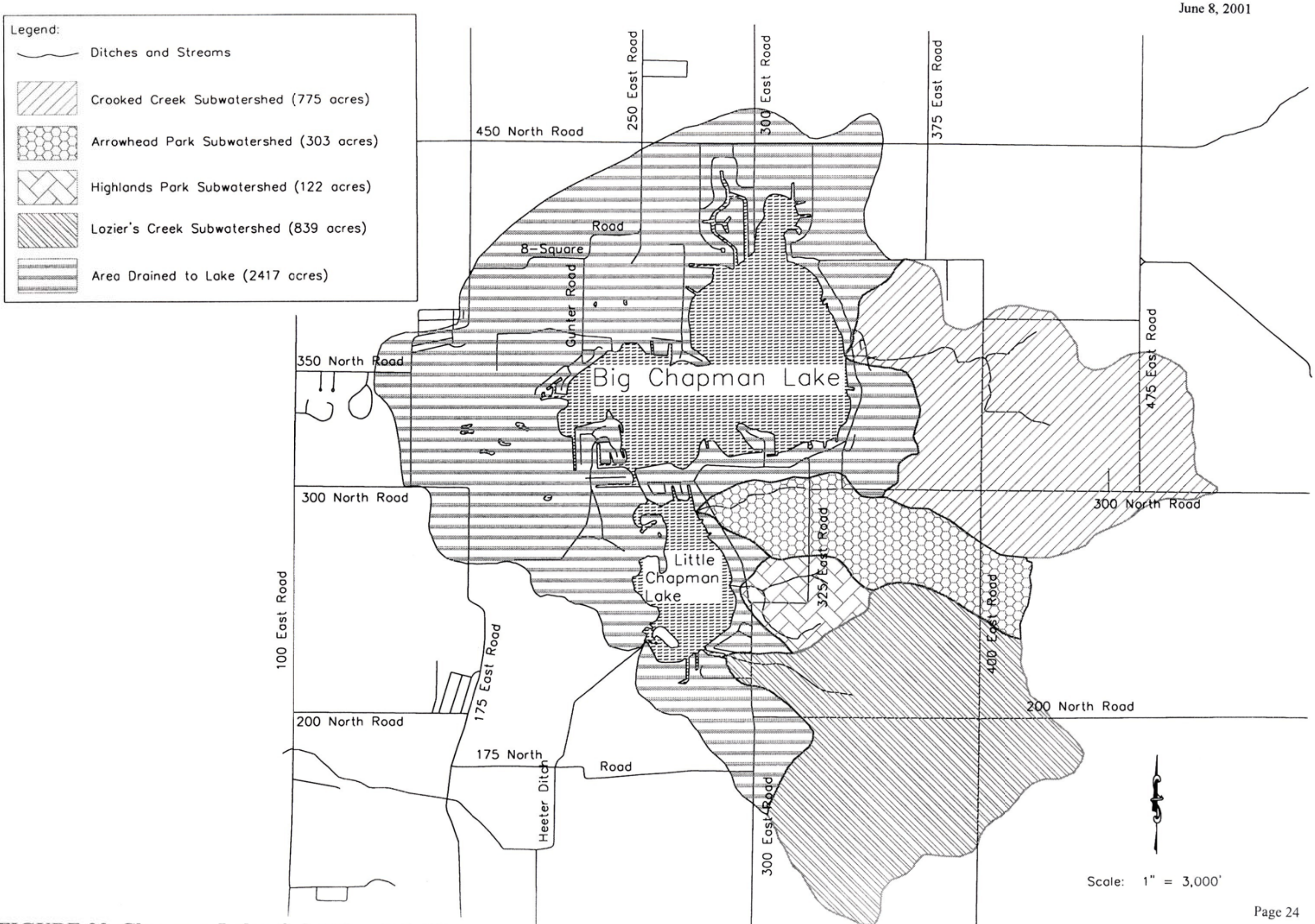


FIGURE 23. Chapman Lakes Subwatersheds Map

Source of Base Map: U.S.G.S. 7.5 Minute Topographic Map

For comparison, approximately 112 square miles (290 square km) of land drain to the 768-acre (311 ha) Lake Tippecanoe. This results in a watershed to lake area ratio of approximately 93:1. As a result, Lakes Tippecanoe's watershed can potentially exert a greater influence on the health of Lake Tippecanoe than the Chapman Lakes' watershed can on the Chapman Lakes. Conversely, since the shoreline area around the Chapman Lakes accounts for a larger portion of its watershed, shoreline activities can potentially have a greater impact on the overall health of the Chapman Lakes than shoreline activities do at Lake Tippecanoe. This means that Chapman Lakes residents have more direct control over their lakes' health than is typical.

CLIMATE

Indiana Climate

Indiana's climate can be described as temperate with cold winters and warm summers. "Imposed on the well known daily and seasonal temperature fluctuations are changes occurring every few days as surges of polar air move southward or tropical air moves northward. These changes are more frequent and pronounced in the winter than in the summer. A winter may be unusually cold or a summer cool if the influence of polar air is persistent. Similarly, a summer may be unusually warm or a winter mild if air of tropical origin predominates. The action between these two air masses of contrasting temperature, humidity, and density fosters the development of low-pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. These systems are least active in midsummer and during this season frequently pass north of Indiana" (National Climatic Data Center, 1976). Prevailing winds are generally from the southwest, but are more persistent and blow from a northerly direction during the winter months.

Kosciusko County Climate

The climate of Kosciusko County is characterized as cool and humid with winters that typically provide enough precipitation, in the form of snow, to supply the soil with sufficient moisture to minimize drought conditions when the hot summers begin. Winters are cold, averaging 26ºF (-3ºC), while summers are warm, averaging 70ºF (21ºC). The highest temperature ever recorded was 103ºF (39ºC) on July 17, 1976. Mild drought conditions do occur occasionally during the summer when evaporation is highest. Average relative humidity differs very little over the course of a day and is often 100 percent during summer months. In 2000, just over 34 inches (86 cm) of precipitation (Table 2) was recorded at Warsaw, Indiana in Kosciusko County (http://shadow.agry.purdue.edu/sc.index.html). The average annual precipitation is 34.88 inches (88.6 cm). Although the difference between the annual total precipitation in 2000 compared to the annual average is not drastic, the year was characterized by significant wetter-than-normal and drier-than-normal periods. During 2000, the spring period (during the months of March and April) was drier than normal, while the area received two inches more than normal in both May and June. However, July, September, and October through December each saw less than normal amounts of precipitation.

TABLE 2. Monthly rainfall data for year 2000 as compared to average monthly rainfall. Averages are based on available weather observations taken during the years of 1961-1990 (http://shadow.agry.purdue.edu/sc.index.html).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
2000	1.25	1.83	1.41	3.01	5.06	6.68	1.86	3.56	4.47	1.07	2.55	1.32	34.07
Average	1.62	1.45	2.19	3.14	3.46	4.01	3.62	3.49	3.35	2.88	2.83	2.84	34.88

The soil usually becomes saturated with water several times during the winter and spring. The water table offers abundant water storage in ancient lake and stream beds which are currently overlain by glacial deposits from the Pleistocene glacial recession. Flooding is common in Indiana and occurs in some part of the state almost every year. The months of greatest flooding frequency are December through April. Causes of flooding vary from prolonged periods of heavy rain to precipitation falling on snow and frozen ground.

SOILS

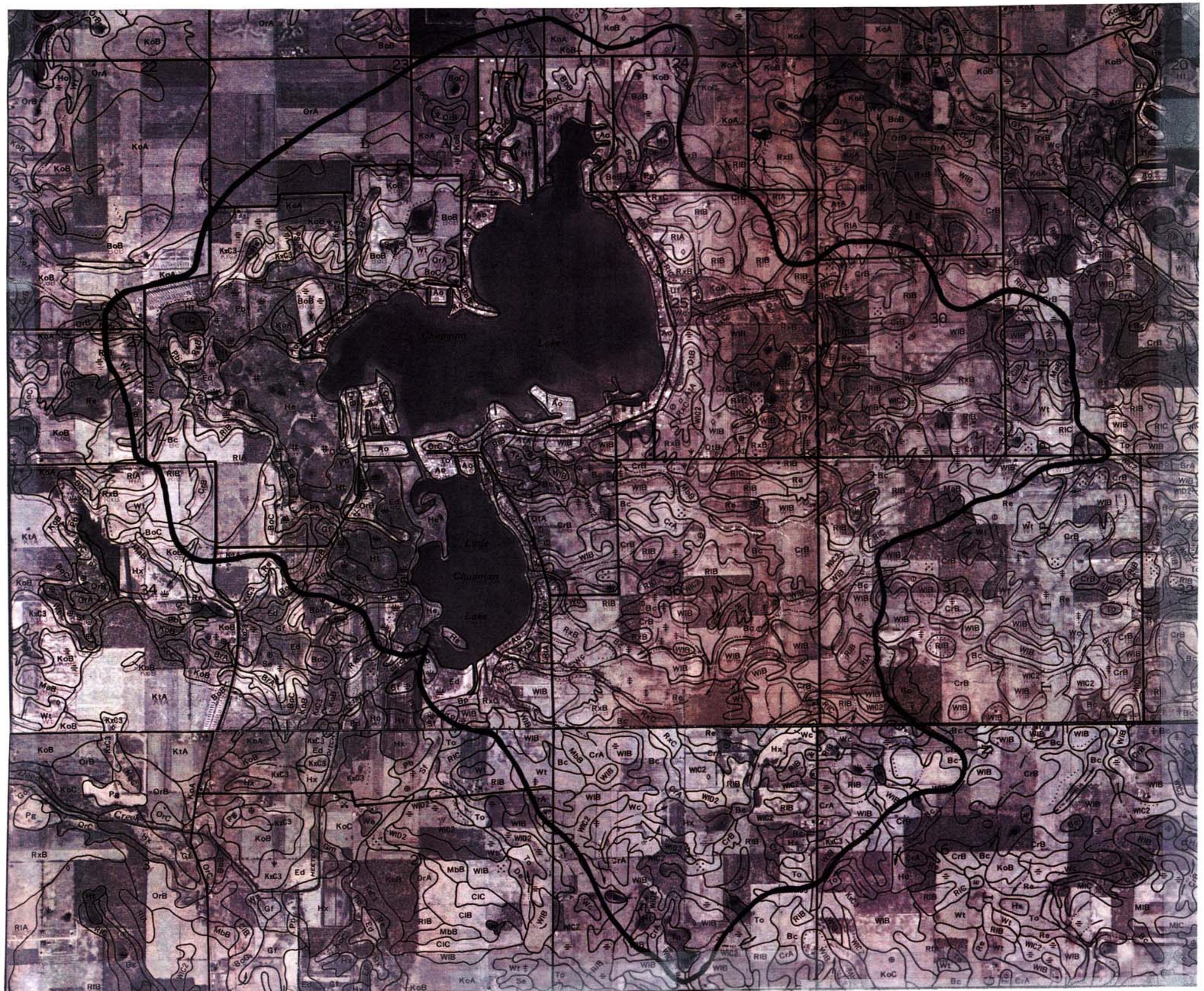
The soil types found in Kosciusko County are a product of the original parent materials deposited by the glaciers that covered this area 12,000 to 15,000 years ago. The main parent materials found in these two counties are glacial outwash and till, lacustrine material, alluvium, and organic materials that were left as the glaciers receded. The interaction of these parent materials with the physical, chemical, and biological variables found in the area (climate, plant and animal life, time, and the physical and mineralogical composition of the parent material) formed the soils of Kosciusko County today.

Specific soil types found in the Chapman Lakes watershed are mapped on Figure 24a. (Figure 24b displays the legend.) Soils in the watershed, and in particular their ability to erode or sustain certain land use practices, can impact the water quality of a lake. For example, highly erodible soils are, as their name suggests, easily erodible. Soils that erode from the landscape are transported to waterways or waterbodies where they impair water quality and often interfere with recreational uses by forming sediment deltas in the waterbodies. In addition, such soils carry attached nutrients, which further impair water quality by fertilizing macrophytes (rooted plants) and algae. Soils that are used as septic tank absorption fields deserve special consideration as well. The presence of highly erodible soils and the use of septic fields in the Chapman Lakes watershed are described in further detail below.

Highly Erodible Soils

Figure 25 maps the presence of highly erodible soils and potentially highly erodible soils in the Chapman Lakes watershed. (It is important to note that this map is based on the Natural Resources Conservation Service (NRCS) criteria for highly erodible soils and is not field checked.) Only 50 acres (20 ha) of land are mapped as highly erodible soils in the watershed (Table 3). This acreage is concentrated in the upper reaches of the Lozier's Creek subwatershed and north of the Island Park neighborhood in the northwest corner of Big Chapman Lake. Approximately 1,334 acres (540 ha) of land in the watershed are mapped in potentially highly erodible units. By subwatershed, the Crooked Creek subwatershed has the greatest percentage of land (50%) mapped as potentially highly erodible units. The Lozier's Creek and Highlands Park subwatersheds drainage nearly equal that percentage; approximately 47% of the land in each of

CHAPMAN LAKES WATERSHED



Source of Map: Natural Resource Conservation Service of Kosciusko County

JFNA# 99-04-01

J.F. New & Associates, Inc.
708 Roosevelt Road
P.O. Box 243
Walkerton, IN 46574
Phone: 219-586-3400
FAX: 219-586-3446

Permitting • Delineations • Mitigation Design • Biological Inventories
Wetland and Prairie Nursery • Lake and Stream Enhancement
Natural Systems for Wastewater Treatment

FIGURE 24.a. Soil Map

Scale: 1" = 2,266'

Soils Legend:

Ao	Aquents-Urban land complex
AtA	Aubbeenaubbee fine sandy loam, 0-2% slope
Bc†	Barry loam
BoB	Boyer loamy sand, 0-6% slope
BoC*	Boyer loamy sand, 6-12% slope
ClB	Coloma loamy sand, 0-6% slope
CrA	Crosier loam, 0-1% slope
CrB	Crosier loam, 1-4% slope
De	Del Ray silt loam
Ed†	Edwards muck, drained
Gf†	Gilford sandy loam
Go†	Gravelton loamy sand
He†	Histosols and Aquolls
Ho	Homer sandy loam
Ht†	Houghton muck
Hx†	Houghton muck, drained
KoA	Kosciusko sandy loam, 0-2% slope
KoB*	Kosciusko sandy loam, 2-6% slope
KoC*	Kosciusko sandy loam, 6-12% slope
KoE**	Kosciusko sandy loam, 18-30% slope
KtA	Kosciusko silt loam
KxC3**	Kosciusko sandy clay loam, 8-15% slope, severely eroded
MaB*	Martinsville sandy loam, 2-6% slopes
MbB	Metea loamy sand, 2-6% slope
OrA	Ormas loamy sand, 0-2% slope
OrB	Ormas loamy sand 2-6% slope
OrC*	Ormas loamy sand, 6-12% slope
OtA	Ormas loamy sand, 0-2% slope
OtB	Ormas loamy sand, 2-6% slope
Pg*	Pits, gravel
Pb†	Palms muck, gravelly substratum, drained
Re†	Rensselaer loam
RlA	Riddles fine sandy loam, 0-2% slope
RlB*	Riddles fine sandy loam, 2-6% slope
RlC*	Riddles fine sandy loam, 6-12% slope
RxB*	Riddles-Ormas-Kosciusko complex, 2-6% slope
RxC*	Riddles-Ormas-Kosciusko complex, 6-12% slope
Se†	Sebewa loam
To†	Toledo silty clay
Uf	Udorthents-Urban land complex
Wc†	Washtenaw silt loam
We†	Washtenaw loam
WlB*	Wawasee fine sandy loam, 2-6% slope
WlC2*	Wawasee fine sandy loam, 6-12% slope, eroded
WlD2**	Wawasee fine sandy loam, 12-18% slope, eroded
Wt	Whitaker loam

† Hydric soils
* Potentially highly erodible soils
** Highly erodible soils

JFNA# 99-04-01

FIGURE 24b. Soil Map Legend

J.F. New & Associates, Inc.
708 Roosevelt Road
P.O. Box 243
Walkerton, IN 46574
Phone: 219-586-3400
FAX: 219-586-3446

Permitting • Delineations • Mitigation Design • Biological Inventories
Wetland and Prairie Nursery • Lake and Stream Enhancement
Natural Systems for Wastewater Treatment

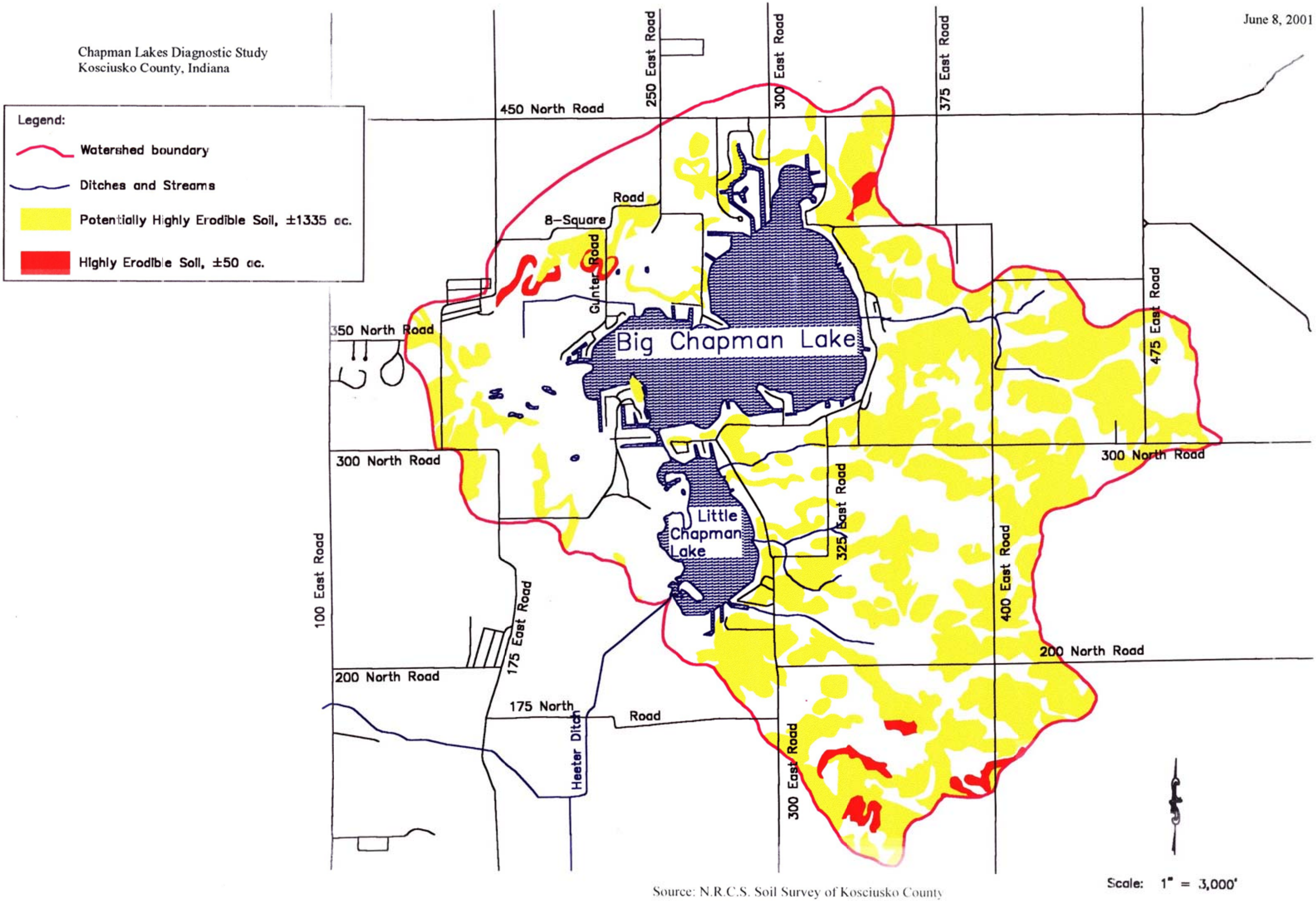


FIGURE 25. Highly Erodible and Potentially Highly Erodible Soil Map

those subwatersheds is mapped in potentially highly erodible units. The Arrowhead Park subwatershed and land that drains directly to the lakes have lower percentages of land mapped in potentially highly erodible units (31% and 21%, respectively).

TABLE 3: Area Mapped in Highly Erodible or Potentially Highly Erodible Map Units by Subwatershed.

	Highly Erodible Soil			Potentially Highly Erodible Soils		
Subwatershed	**Acres**	**Hectares**	**Percent of watershed**	**Acres**	**Hectares**	**Percent of watershed**
Crooked Creek	0	0	0%	389.2	157.6	50.2%
Lozier's Creek	28.3	11.5	3.4%	392.0	158.7	46.8%
Arrowhead Park Drainage	0	0	0%	92.6	37.5	30.6%
Highlands Park Drainage	0	0	0%	52.2	21.3	47.0%
Area adjacent to lake	21.8	8.8	2.8%*	408.6	165.4	21.3%*
Total	**50.1**	**20.3**	**1.3%***	**1334.6**	**540.3**	**33.8%***

*Area of lakes not included in percentage calculation

Highly Erodible Land

Highly Erodible Land (HEL) is a designation used by the Farm Service Agency (FSA). For a field to be labeled HEL by the FSA, at least one third of the parcel must be situated in highly erodible soils. Unlike the soil survey, these fields must be field checked to ensure the accuracy of the mapped soil types. Farms fields mapped as HEL are required to file a conservation plan with the FSA in order to maintain eligibility for any financial assistance from the U. S. government. Figure 26 shows the location of HEL fields in the Chapman Lakes watershed. Approximately 137 acres (56 ha) of HEL exists in the Chapman Lakes watershed. The entire acreage is confined to the upper portion of the Lozier's Creek subwatershed.

Septic System Use

As is common in rural areas, septic tanks and septic tank absorption fields are utilized for wastewater treatment in the Chapman Lakes watershed. This type of wastewater treatment system relies on the septic tank for primary treatment to remove solids and the soil for secondary treatment to reduce the remaining pollutants in the effluent to levels that protect the groundwater from contamination. Groundwater is one of the water sources to the lakes. Consequently, the type of soil located adjacent the Chapman Lakes and the soil's ability to function as a septic tank absorption field will affect the lakes' water quality.

A variety of factors can affect a soil's ability to function as a septic absorption field. Whether or not a soil is typically ponded during a portion of the year has obvious impacts on its ability to serve as a septic field. Frequently ponded soils offer little or no treatment to waste effluent. Untreated effluent is often simply flushed to the lake. Soils located on sloped land may have difficulty in treating wastewater as well. Septic fields sited on these soils may require enlarged fields to treat the waste effluent. Soils that have been disturbed through excavation and fill or compaction are also unsuitable for wastewater discharge using soil absorption fields.

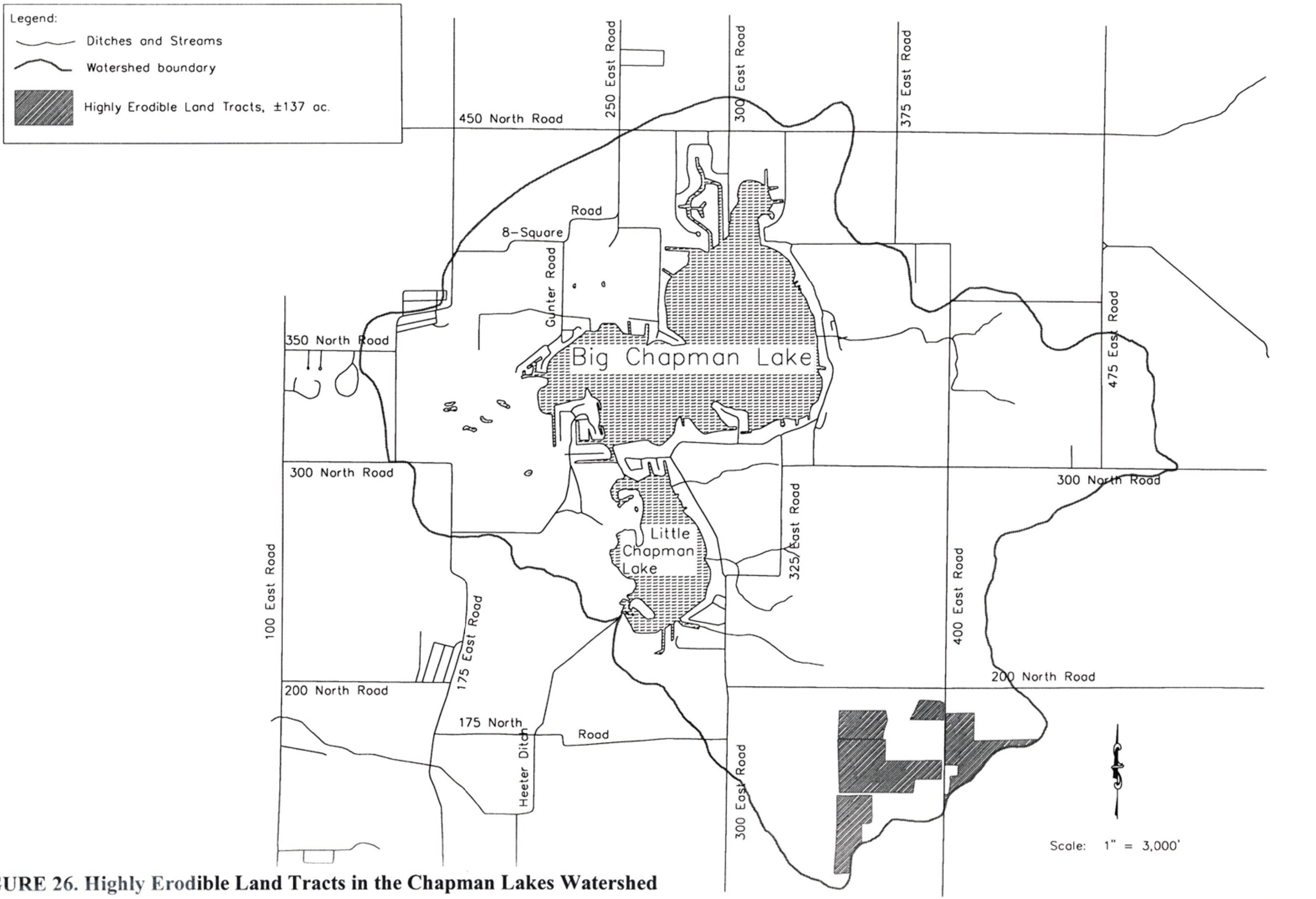
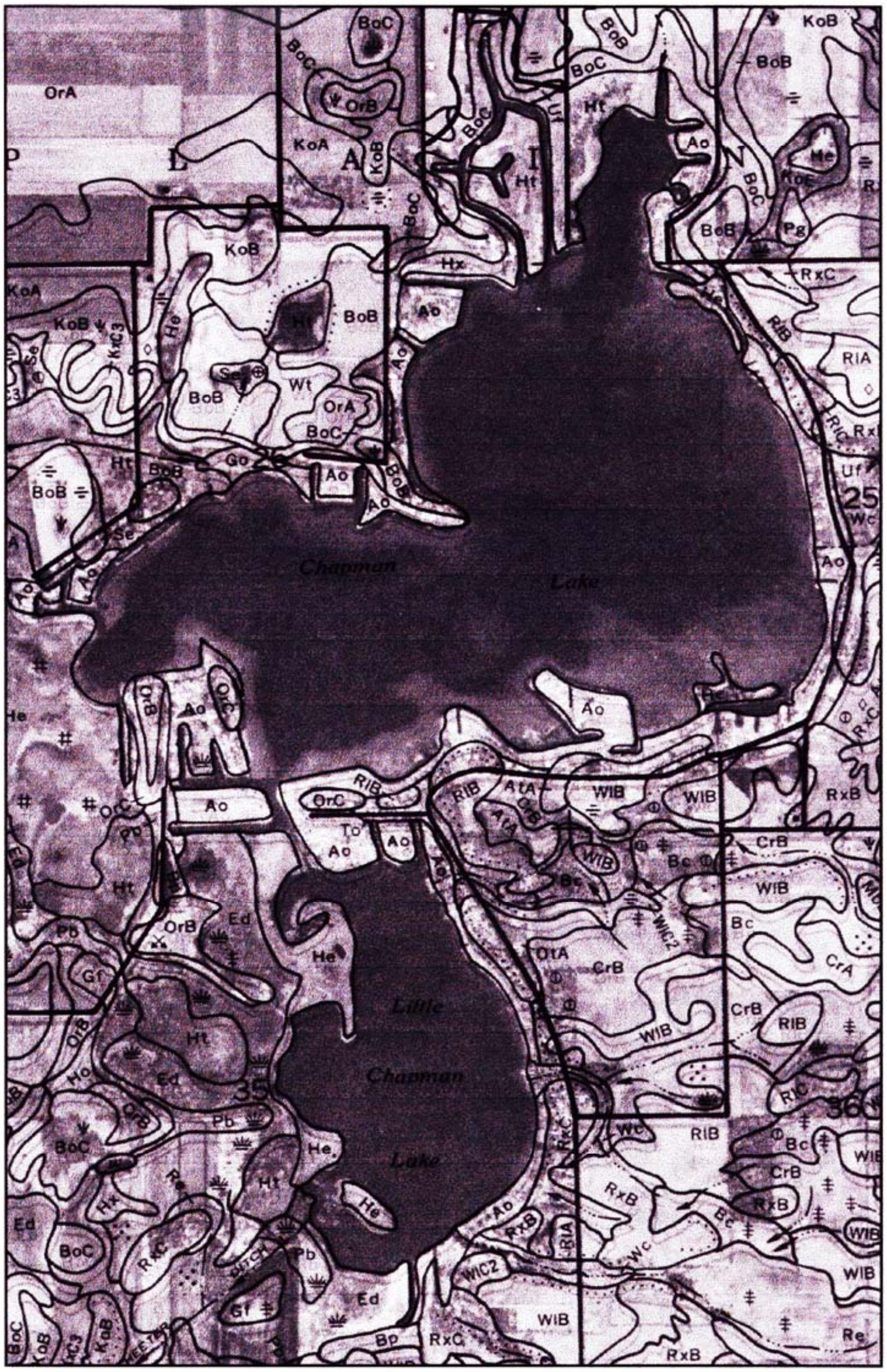


FIGURE 26. Highly Erodible Land Tracts in the Chapman Lakes Watershed

In addition, soils with very slow percolation rates are limited in their ability to serve as septic fields. These soils can become clogged due to the high levels of organic material in the septic effluent. Like soils on sloped land, these soil types require very large absorption fields due to the low permeability of the soil. Soils with slow percolation rates are prone to septic failure resulting in overland flow of untreated septic effluent to the adjacent lake. Conversely, in soils with very rapid percolation rates, effluent travels quickly through the soil to the groundwater without being treated. Contaminated groundwater often reaches the lakes as well.

The NRCS ranks each soil series in terms of its limitations for use as a septic tank absorption field. Each soils series is placed in one of three categories: slightly limited, moderately limited, or severely limited. Use of septic absorption fields on soils in the moderately or severely limited soils generally requires special designs, planning, or maintenance to overcome the limitations. Table 4 summarizes the soil series located adjacent to the Chapman Lakes in terms of their suitability for use as a septic tank absorption field. Figure 27 shows the location of soil types adjacent to the Chapman Lakes.



Soils Legend:

Ao	**Aquents-Urban land complex**
He†	**Histosols and Aquolls**
Ed†	**Edwards muck**
Ht†	**Houghton muck, undrained**
Hx†	**Houghton muck, drained**
Pb†	**Palms muck**
Se†	**Sebewa loam**
To†	**Toledo silty clay loam**
Wc†	**Washtenaw silt loam**
Go†	**Gravelton loamy sand**
Bp	**Brady sandy loam**
RlB	**Riddles fine sandy loam**
WlC2	**Wawasee fine sandy loam**
RxC	**Riddles-Ormas-Kosciusko complex**
Uf	**Udorthents-Urban land complex**
KoA	**Kosciusko sandy loam**
BoB, BoC	**Boyer loamy sand**
OrB, OrC	**Ormas loamy sand**

Scale: 1" = 1,667 ft

JFNA# 99-04-01

Figure 27. Soil Types Adjacent to the Chapman Lakes

J.F. New & Associates, Inc.
708 Roosevelt Road
P.O. Box 243
Walkerton, IN 46574
Phone: 219-586-3400
FAX: 219-586-3446

Permitting • Delineations • Mitigation Design • Biological Inventories
Wetland and Prairie Nursery • Lake and Stream Enhancement
Natural Systems for Wastewater Treatment

TABLE 4. Soil Types Adjacent to the Chapman Lakes.

Symbol	Name	High Water Table	Suitability for Septic Tank Absorption Field
Ao	Aquents-Urban land complex, rarely flooded	-	unsuitable: flooding
He	Histosols and Aquolls	-	unsuitable: ponding
Ed	Edwards muck, drained	+1-0.5 ft	severe: ponding, percs slowly
Ht	Houghton muck, undrained	+1-1.0 ft	severe: subsides, ponding, percs slowly
Hx	Houghton muck, drained	+1-1.0 ft	severe: subsides, ponding, percs slowly
Pb	Palms muck, gravelly substratum, drained	+1-1.0 ft	severe: subsides, flooding, ponding
Se	Sebewa loam	+1-1.0 ft	severe: poor filter, ponding
To	Toledo silty clay	+1-1.0 ft	severe: ponding, perks slowly
Wc	Washtenaw silt loam	+0.5-1.0 ft	severe: ponding, perks slowly
Go	Gravelton loamy sand	+1-1.0 ft	severe: flooding, ponding, poor filter
Bp	Brady sandy loam	1-3 ft	severe: wetness
RlB	Riddles fine sandy loam	>6.0 ft	moderate: perks slowly
WlC2	Wawasee fine sandy loam	>6.0 ft	moderate: slope, perks slowly
RxC	Riddles-Ormas-Kosciusko complex	>6.0 ft	moderate to severe: poor filter
Uf	Udorthents-Urban land complex	-	suitability varies
BoB, BoC	Boyer loamy sand	>6.0 ft	severe: poor filter
KoA	Kosciusko sandy loam	>6.0 ft	severe: poor filter
OrB, OrC	Ormas loamy sand	>6.0 ft	severe: poor filter

Source: Soil Survey of Kosciusko County

Aquents-Urban land complex, rarely flooded (Ao) typically occurs on the edges of lakes, where marshes have been filled with soil material. This unit is rarely flooded, except for brief periods by stream or lake overflow. In many areas, it is ponded by runoff from the higher adjacent soils. The physical characteristics of the Aquents are highly variable, and suitability for use depends on the thickness and texture of the fill, depth to the seasonal high water table, and the nature of the underlying material. Because of the flooding, the soils are generally unsuitable as sites for buildings and septic tank absorption fields. Under current Indiana regulations, it is illegal to place septic systems in these soils.

The Histosols and Aquolls (He) are very poorly drained soils frequently ponded by runoff from the higher adjacent soils or by lake or stream overflow. The water table is typically near or above the surface most of the year, which makes these soils generally unsuitable for septic tank absorption fields.

The Edwards muck, drained (Ed), Toledo silty clay (To), and Washtenaw silt loam (Wc) are poorly drained soils with a water table near or above the surface most of the year. Due to the seasonal high water table, these soils are severely limited for septic tank absorption fields.

Drained (Hx) and undrained (Ht) Houghton muck and drained Palms muck (Pb) are poorly drained soils usually found in depressions and frequently ponded by lake water or runoff from higher areas. Because of the ponding and high water table, these soils are poorly suited for septic tank absorption fields.

Sebewa loam (Se) and Gravelton loamy sand (Go) soils are situated in level, low-lying areas adjacent to major drainage areas. They are very poorly drained and are often flooded by stream overflow during periods of runoff. Septic suitability is severely limited for these soils due to the likelihood of flooding and ponding.

The Brady sandy loam (Bp) soils are somewhat poorly drained. The water table is near, though never above, the surface as is the case with the Histosols and Aquolls. These soils are rated as severely compromised for septic systems because of wetness and because the subsoils are moderately rapidly permeable, and the underlying material is very rapidly permeable.

Riddles fine sandy loam (RlB) are well-drained soils that are moderately limited for septic system use due to moderate permeability. Enlarged septic fields built within this soil type will better absorb effluent. The Wawasee fine sandy loam (WlC2) soils are also moderately limited for septic suitability. Moderate slopes and permeability may limit the ability of the field to absorb the effluent.

Riddles-Ormas-Kosciusko complex (RxC) are well-drained soils on moderate slopes. The moderate slopes limit septic field suitability. The Ormas component of the complex is a poor effluent filter which may result in groundwater pollution especially if septic systems are situated near shallow wells.

The suitability of Udorthents-Urban land complex (Uf) for septic tanks varies among locales. The Udorthents-Urban land complex is a moderately steep, well-drained soil combined with urban land. Septic suitability limitations can include restricted permeability, wetness, and steep slopes.

Rapid permeability impairs ability of the remaining five soil types adjacent to the Chapman Lakes to serve as septic absorption fields. Boyer loamy sands (BoB, BoC), Kosciusko sandy loams (KoA), and Ormas loamy sands (OrB, OrC) are well-drained soils. Permeability is moderate in the subsoil and very rapid in the underlying material. Due to the rapid permeability of these five soil types, they do not provide adequate filtering capability for septic tank absorption fields and may cause pollution of the ground water.

Soil Discussion and Summary

The type of soils in a watershed and the land uses practiced on those soils can affect a lake's health. Highly erodible soils are concentrated northwest of Big Chapman Lake and in the southern portion of the watershed. Soil erosion contributes sediment to the lakes reducing the lake's water quality and interfering with recreational uses of the lakes. Nutrients attached to eroded soils will help fertilize algae and rooted plants. Consequently, conservation methods and best management practices (BMPs) should be utilized when soils are disturbed in these areas. This includes development of shoreline property as well as farming in highly erodible soils.

Soil type should also be considered in siting septic systems. Some soils do not provide adequate treatment for septic tank effluent. Much of the Chapman Lakes shoreline is mapped in soils that rate as severely limited or generally unsuitable for use as a septic tank absorption field. This is typical for much of Indiana. Research by Dr. Donald Jones suggests that 80% of the soils in Indiana are unsuitable for use as a septic tank absorption field (Grant, 1999). The increased density of housing and the conversion of summer cottages to fulltime living quarters have exacerbated the situation.

The resident survey indicates that conversion of summer cottages to fulltime living quarters has occurred around the Chapman Lakes. Thirty nine percent of the respondents who owned new homes (1+ years) reported having septic systems older than 5 years old. It cannot be determined from the survey if these septic systems are appropriately sized for the newer residence, which are likely larger than the original residence serviced by the septic system. Over fifty percent of the survey respondents noted that they have remodeled their home in the past 15 years. Sixty seven percent of the respondents stated that their residences were equipped with washing machines. These results confirm that the property owners around the lakes are upgrading their homes. Adjustments in septic systems (tank and field size) should accompany any modernization to ensure the system is capable of handling the increased effluent stream.

Pollution from septic tank effluent can affect a lake and its users in a variety of ways. It can contribute to eutrophication, or nutrient enrichment, of the lake which impairs the lake water quality. The nutrients present in septic tank effluent can fertilize algae and macrophytes in the lake promoting algae blooms and macrophyte growth. In addition, septic tank effluent potentially poses a health concern for lake users. Swimmers, anglers, or boaters that have body contact with contaminated water may be exposed to waterborne pathogens. Fecal contaminants can be harmful to humans and cause serious diseases, such as infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illness.

LAND USE

Figure 28 and Table 5 present land use information for the Chapman Lakes watershed. Land use data was obtained from the Indiana Gap Analysis project. This data was checked with recent aerial photography and in some areas field checked. Data was then corrected to reflect current conditions in the watershed. The land use categories shown in Table 5 are general in nature. Appendix 2 breaks the data into more subwatersheds and detailed categories.

Approximately 62% of the watershed is used for agricultural purposes, including cropland, pasture, and agricultural woodlots. This percentage is slightly below the percentage estimated for the county as a whole (72%) (U.S. Census of Agriculture, 1999). Wetlands and open water (the lakes) account for approximately 25% of the watershed land. The residential community around the lakes occupies less than 5% of the total watershed.

TABLE 5. Land Use in the Chapman Lake Watershed.

Land use	Area (acres)	Area (hectares)	Percent of watershed
Row crop	2705.1	1095.2	59.3
Wetland	523.0	211.7	11.5
Forested	368.3	149.1	8.1
Residential/urban	221.8	89.8	4.9
Pasture	140.0	56.7	3.1
Open water	598.4	242.3	13.1
Total	**4556.6**	**1844.8**	**100%**

Source: Indiana Gap Analysis Project

The percentages shown in Table 5 change when considering land use on a subwatershed basis (See Appendix 2). Agricultural land use dominates the subwatersheds located east of the lakes (Figure 28). Agricultural land accounts for approximately 89% and 85% of the land in the Lozier's Creek and Crooked Creek subwatersheds, respectively. In contrast, agricultural land accounts for only 43% of the land draining directly to the lakes. Most of the watershed's wetlands are located along the western edge of the lakes. Most of the watershed's residential land is concentrated in the area draining directly to the lakes.

Corn, soybeans, and tomatoes are the major crops grown on agricultural land in the Chapman Lakes watershed. Although exact percentages of each crop were not recorded for the watershed, approximately 49% of the cropland in Kosciusko County was planted in corn and 39% in soybeans in 1998 (U.S. Census of Agriculture, 1999). It is likely that the Chapman watershed closely mirrors these percentages. Similarly, while conservation tillage practices were not estimated for the watershed, they are utilized throughout the county. In 1998, no-till was practiced on approximately 17% of the farmland planted in corn. Mulch tillage (a tillage method that leaves at least 30% of residue cover on the surface after planting) was practiced on approximately 13% of the farmland planted in corn. For fields planted in soybeans, the percentage of farmland utilizing conservation tillage methods was higher: 57% in no-till, 25% in mulch-till (Julie Harrold, Kosciusko County SWCD, personal communication).

WETLANDS

Because wetlands perform a variety of functions in a healthy ecosystem, they deserve special attention when examining watersheds. Functioning wetlands filter sediment and nutrients in runoff, store water for future release, provide an opportunity for groundwater recharge or discharge, and serve as nesting habitat for waterfowl and spawning sites for fish. By performing these roles, healthy, functioning wetlands often improve the water quality and biological health of streams and lakes located downstream of the wetlands. The land use table above (Table 5) indicates that wetlands account for approximately 11.5% of the Chapman Lakes watershed. Table 6 presents the acreage of wetlands by type. Figure 29 maps the wetlands in the Chapman Lakes watershed by type.

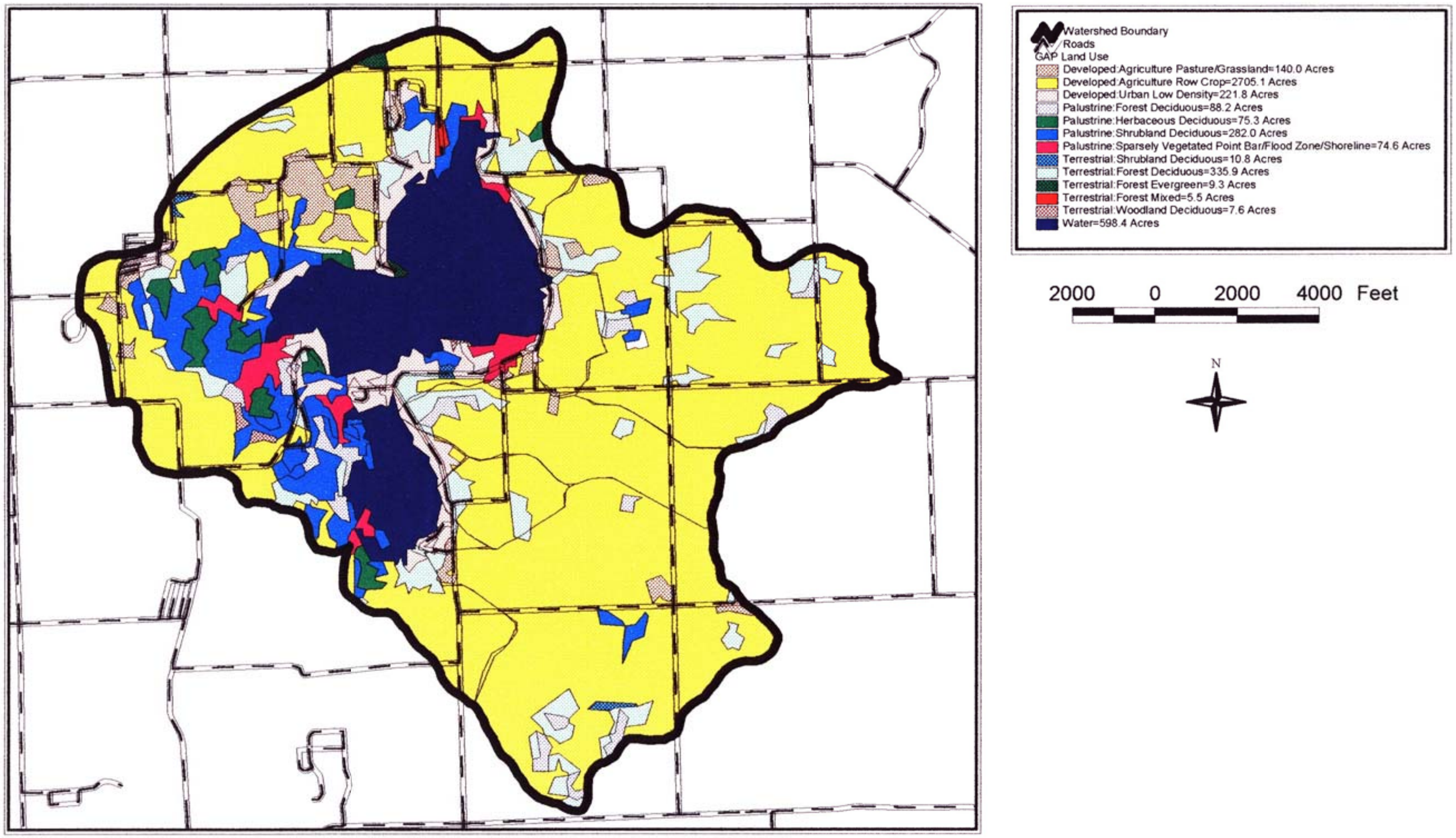
TABLE 6. Acreage and Classification of Wetland Habitat in the Chapman Lakes Watershed.

Wetland Type	Area (acres)	Area (hectares)	Percent of watershed
Forested	88.2	35.7	1.9%
Shrubland	284.9	115.3	6.3%
Herbaceous	149.9	60.7	3.3%
Total	**523**	**211.7**	**11.5%**

Source: Indiana Gap Analysis Project

The IDNR (Indiana Wetland Conservation Plan, 1996) estimates that approximately 85% of the state's wetlands have been filled. The greatest loss has occurred in the northern counties of the state such as Kosciusko County. The last glacial retreat in these northern counties left level landscapes dotted with wetland and lake complexes. Development of the land in these counties for agricultural purposes altered much of the natural hydrology, eliminating many of the wetlands. The 1978 census of agriculture found that drainage is artificially enhanced on 38% of the land in Kosciusko County (cited in Hudak, 1995). Residential development has also decreased the wetland acreage in the watershed. A review of aerial photographs suggests large portions of the Chapman Lakes shorelines were originally wetland habitat. These wetlands were filled to support lakeshore houses.

To estimate the historical coverage of wetlands in the Chapman Lakes watershed, hydric soils in the watershed were mapped on Figure 30. (As noted for the highly erodible soils map, this map is based on the Natural Resources Conservation Service criteria for hydric soils and is not field checked.) Because hydric soils developed under wet conditions, they are a good indicator of the historical presence of wetlands. Comparing the total acreage of wetland (hydric) soils in the watershed (1064 acres or 430.8 ha) to the acreage of existing wetlands (523 acres or 211.7 ha) suggests that only approximately 49% of the original wetland acreage exists today. Table 7 examines wetland loss by subwatershed. The Highland Park subwatershed has experienced the greatest loss with no wetland acreage existing today. The Crooked Creek, Lozier's Creek and Arrowhead Park subwatersheds have suffered significant wetland losses as well with only 12%, 15%, and 18% of the original wetland acreage remaining today. Wetland loss immediately adjacent to the lakes is less severe. True wetland loss in the area immediately adjacent to the lake



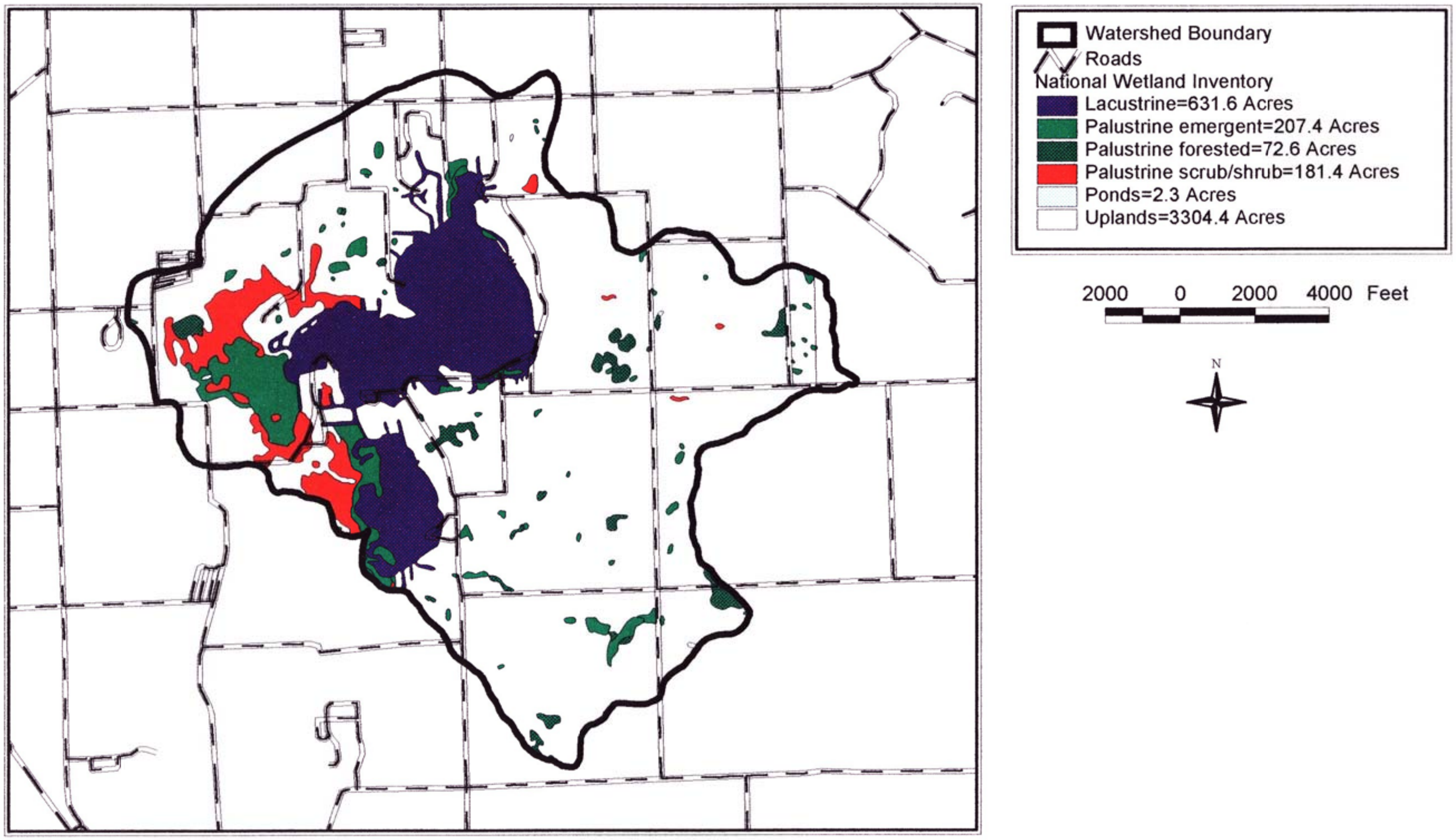
Source: Indiana GAP Analysis

JFNA 99-04-01

Figure 28.
Land Use in the
Chapman Lakes Watershed

J.F. New & Associates, Inc.
706 Roosevelt Road
P.O. Box 243
Walkerton, IN 46574
Phone: 219-586-3400
FAX: 219-586-3446

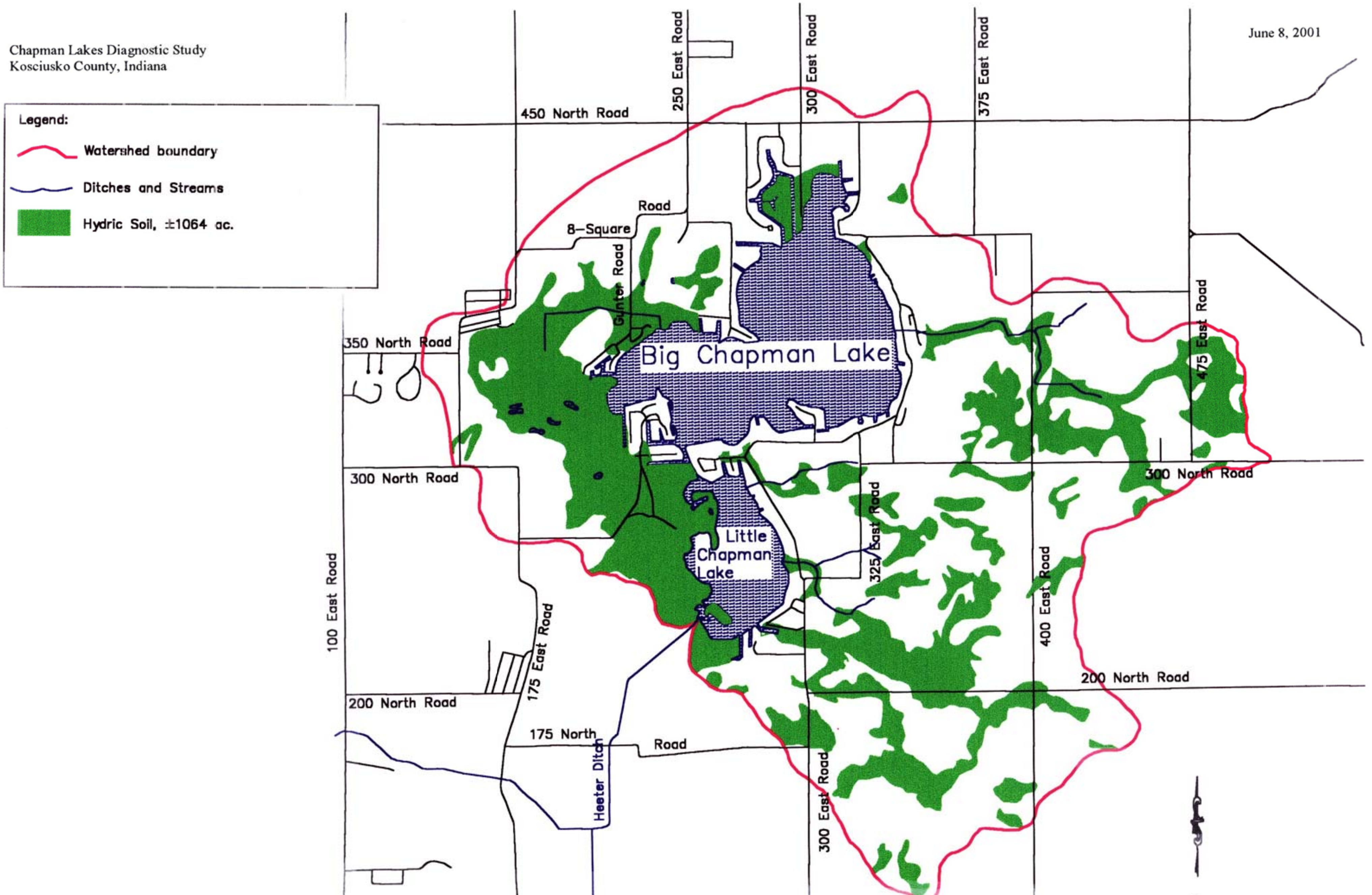
Permitting · Delineations · Mitigation Design · Biological Inventories
Wetland and Prairie Nursery · Lake and Stream Enhancement
Natural Systems for Wastewater Treatment



JFNA 99-04-01

J.F. New & Associates, Inc.
708 Roosevelt Road
P.O. Box 243
Walkerton, IN 46574
Phone: 219-586-3400
FAX: 219-586-3446
Permitting · Delineations · Mitigation Design · Biological Inventories
Wetland and Prairie Nursery · Lake and Stream Enhancement
Natural Systems for Wastewater Treatment

Figure 29.
National Wetland Inventory Map of the
Chapman Lakes Watershed



Source: N.R.C.S. Soil Survey of Kosciusko County

FIGURE 30. Hydric Soil Map

is slightly underestimated by the method used here. Much of the land bordering the lakes is mapped in the Aquents-Urban land complex soil unit. This unit is not listed as a hydric soil unit. However, many areas mapped in this unit were originally marsh areas that were filled with soil for development. Loss in wetland acreage throughout the watershed results in a loss of wetland functions, many of which improve water quality. Restoration of at least some of the wetlands could restore some of these functions.

TABLE 7. Acreage of Wetland Habitat Loss in the Chapman Lakes Watershed.

Subwatershed	**Hydric Soil in Acres (in hectares)**	**Wetland Area in Acres (in hectares)**	**Percent wetland remaining**
Crooked Creek	216.5 (87.6)	30.4 (12.3)	12%
Lozier's Creek	230.5 (93.3)	33.7 (13.6)	15%
Arrowhead Park Drainage	61.6 (24.9)	10.9(4.4)	18%
Highland Park Drainage	21.6 (8.7)	0 (0)	0%
Area adjacent to lakes	533.6 (216.0)	448 (181.4)	84%
Total	**1063.8 (430.7)**	**523 (211.7)**	**49%**

NATURAL COMMUNITIES AND ETR SPECIES

The Indiana Natural Heritage Data Center database provides information on the presence of endangered, threatened, or rare species, high quality natural communities, and natural areas in Indiana. The database was developed to assist in documenting the presence of special species and significant natural areas and to serve as a tool for setting management priorities in areas where special species or habitats exist. The database relies on observations from individuals rather than systematic field surveys by the Indiana Department of Natural Resources (IDNR). Because of this, it does not document every occurrence of special species or habitat. At the same time, the listing of a species or natural area does not guarantee that the listed species is present or that the listed area is in pristine condition. To assist users, the database includes the date that the species or special habitat was last observed and reported in a specific location.

Results from the database search for the Chapman Lakes are presented in Appendix 3. (For additional reference, a listing of endangered, threatened, and rare species documented in Kosciusko County is included in Appendix 4). The Big Chapman Lake Nature Preserve area supports four different high quality community types according to the database: marl beach, marsh, sedge meadow, and shrub swamp wetlands. These high quality communities provide habitat for three state endangered animal species, the northern harrier (*Circus cyaneus*), the Virginia rail (*Rallus limicola*), and the blanding's turtle (*Emydoidea blandingii*). Circumneutral bogs, marsh wetlands, and sedge meadow wetlands have been documented within the Little Chapman Lake Nature preserve. The wetland community in this area is inhabited by the marsh wren (*Cistothorus palustris*), least bittern (*Ixobrychus exilis*), black-and-white warbler (*Mniotilta varia*), black-crowned night-heron (*Nycticorax nycticorax*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), and the golden-winged warbler (*Verivora chrysoptera*). All of these birds are state endangered species or species of special concern. The state endangered blanding's turtle and the state rare green-keeled cotton-grass (*Eriophorus viridicarinatum*) were also observed within the Little Chapman Lake Nature Preserve.

SHORELINE DEVELOPMENT

Old maps and aerial photography from the 1900's to the present (see Appendix 5) illustrate the development patterns around Big and Little Chapman Lakes. In his 1900 Report of the State, Geologist Blatchley describes the lake as being irregular in shape with flat gradual banks around some portions of the lake and steeper banks rising 20 feet (6 m)above the water level in other parts of the lake. (Blatchley considered Big and Little Chapman Lakes one lake, Little Eagle Lake.) He describes a narrow channel through marsh habitat connecting the main basin to its southern arm (Little Chapman Lake). Blatchley claims that the lake was lowered twice prior to his survey resulting in the exposure of the wetland flats along the western portion of Big and Little Chapman Lakes. He estimates the loss in surface area from this lowering to be approximately 150 acres.

A 1938 photograph of Big Chapman Lake and the northern half of Little Chapman Lake show the large wetland expanses on the west side of the lakes. Wetland fringes are also present along much of Big Chapman Lake, particularly around Nellie's Bay, the area immediately west of Nellie's Bay, the area west of Hog's Point, Osborn's Landing, and Arrowhead. Roads bordering the eastern shore and providing access to the lake at high points are visible in the photograph. With this access, it is likely that seasonal cottages dotted the eastern shoreline of both lakes by the late 1930's although large portions of the lakes remained undeveloped.

Photos of Big Chapman Lake from the late 1940's confirm the presence of seasonal cottages along the eastern and southern shorelines. Much of the northern and western portions of the lake are undeveloped. The 1940's photographs show channels cut through the natural wetland fringe along the southern shoreline and around what will become the Arrowhead neighborhood. These channels provide further evidence of development around the lakes.

Modern development around the lakes exploded in the late 1940's and 1950's. A 1957 photograph shows the development of channels in Nellie's Bay, Osborn's Landing, between the lakes, and in various places around the lakes. Much of the southern shoreline and parts of the northeast and northwest shoreline were dredged to provide access to the lake through the natural wetland fringe. Despite the presence of these channels, residences are largely confined to the eastern and southern portions of Big Chapman Lake and the eastern shoreline of Little Chapman Lake. A few homes are also located on Hog's Point, between the lakes, and Osborn's Landing.

Development of the lakes continued in the 1960's and 1970's. A 1964 Indiana Department of Natural Resources (IDNR) Fisheries Report states that nearly 90% of the Big Chapman Lake shoreline is developed (McGinty, 1964). The report notes 277 cottages and 51 trailer homes line the shore and channels on Big Chapman. By 1973, channels were cut through the wetlands west of Hog's Point and west of Island Park to support more development. Additional channels were added to Osborn's Landing, and Nellie's Bay providing more lakefront access. Homes dotted the Hog's Point and Arrowhead peninsulas. Increased density in the between the lakes area, Osborn's Landing, and along the northwest and eastern shorelines is also noticeable in the 1970's photographs. A 1976 IDNR Fisheries Report estimates that nearly 50% of the Little Chapman Lake is developed with 121 homes (Shipman, 1976).

Growth around the lakes began to taper-off in the 1980's and 1990's but it did not cease altogether. In a survey of lakes in Koscuisko County, Hippensteel (1989) reports 346 homes bordering Big Chapman Lake and 108 homes around Little Chapman Lake in 1980. Remodeling became more popular as space and new environmental laws limited new development of the existing shoreline on both lakes. Evidence of this is supported by the resident survey in which 75% of the respondents noted they had remodeled their house in the past 20 years. In some cases, cottages were razed and replaced with newer residences in which property owners lived fulltime rather than seasonally.

Currently, approximately 448 residences (houses, cottages, trailer homes) line the shoreline and channels of Big Chapman Lake, while 175 border Little Chapman Lake. Numerous homes that do not lie on lakefront property also exist around the lakes. As indicated by the resident survey, most of these homes are more than 20 years old (80%). Seawalls protect nearly 80% of these lakefront homes. No significant areas of shoreline erosion were noted during a shoreline reconnaissance survey, likely due to the heavy seawall use on the lakes. The seawalls consist largely of concrete and rock materials. Concrete seawalls are most common in areas that were formerly wetland habitat, although their presence was noted along other areas of the shore as well. Maintained lawns are common habitat behind seawalls. Natural shoreline fronted few residences.

While seawalls provide some temporary erosion control along shorelines, they cannot provide all the functions of a healthy shoreline plant community. Native shoreline communities filter runoff water to the lake, protect the shore from wave action limiting erosion, release oxygen to the water column for use by aquatic biota, and provide food, cover, and spawning/nesting habitat for a variety of fish, waterfowl, insects, mammals, and amphibians. Removal of the native plant community eliminates many of these functions.

INLET STREAM SAMPLING

Background Information and Methods

Analysis of water quality parameters in inlet streams is important for understanding which substances and in what amounts are being introduced to the lakes from the watershed. Five major inlets around Big and Little Chapman Lake and the lakes' outlet were sampled. Two additional sites (3a, 3b) on Crooked Creek were sampled for *Escherichia coli* (*E. coli*) bacteria during the baseflow sampling. Figure 31 maps each sampling location. These include:

Site 1: Lozier's Creek
Site 2: Arrowhead Park Drain
Site 3: Crooked Creek
Site 4: Island Park Drain
Site 5: Outlet
Site 6: Highlands Park Drain

Samples were collected on two dates: one following a storm event and the other during normal or "base flow" conditions. (The Highlands Park Drain (Site 6) was sampled only during base flow.) A base flow sampling provides an understanding of typical conditions in the Chapman Lakes inlet and outlet streams. Following storm events, the increased water flow overland results in increased erosion of soil and nutrients from the land. Thus, the inlet concentrations of nutrients and sediment are higher following storm events. In essence, storm sampling presents a "worst case" picture of the watershed pollutant loading. The storm event samples were taken on September 12, 2000 following a storm that dumped more than six inches of rain on the watershed. Approximately 5.9 inches fell in less than an hour (as measured by a Warsaw resident's rain gage) making the storm event greater than a 100-year event. Due to the magnitude of the storm event, the soils were likely saturated at the time of sampling. It should be noted that this was an atypical storm event that likely produced atypical runoff from the watershed. Because the data is used to rank potential loading from each subwatershed relative to one another rather than obtain exact measurements of loading, results from this sampling were deemed acceptable. The base flow samples were collected on October 12, 2000 following a dry weather period.

Collected samples were stored on ice and transported the same day as collection to Turner Technologies, Inc. in Warsaw, Indiana. (Because the appropriate medium was not prepared for *E. coli* analysis at Tuner Technologies, the October 12 samples for *E. coli* were taken to EIS Analytical Laboratories in South Bend, Indiana.) Turner Technologies analyzed the samples for the following parameters: ammonium (NH_3), nitrate+nitrite nitrogen ($NO_3^- + NO_2^-$), total Kjeldahl nitrogen (TKN), total phosphorus (TP), orthophosphorus (OP), total suspended solids (TSS), pH, conductivity, and *E. coli* (for the September 12 samples only). Appendix 6 provides copies of the laboratory reports for the samples.

There are two useful ways to report water quality data in flowing water. *Concentrations* describe the mass of a particular material contained in a unit of water, for example, milligrams of phosphorus per liter (mg/l). *Mass loading* on the other hand describes the mass of a particular material being carried per unit of time. For example, a high concentration of phosphorus in a stream with very little flow will deliver a smaller total amount of phosphorus to the lake than

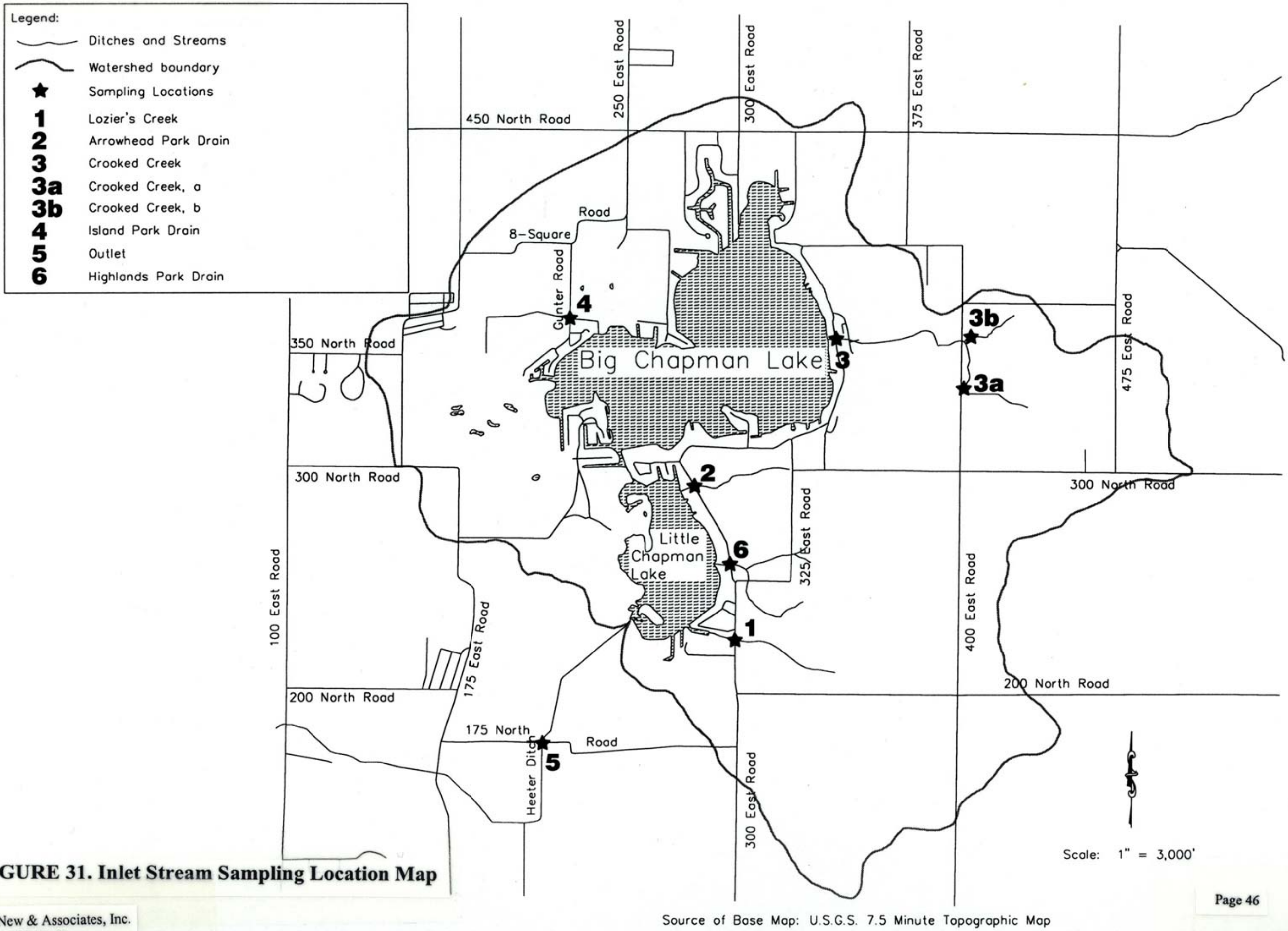


FIGURE 31. Inlet Stream Sampling Location Map

will a stream with a low concentration of phosphorus but a high flow of water. It is the total amount (mass) of phosphorus, solids, and bacteria actually delivered to the lake that are the most important when considering the effects of these materials on a lake.

Results and Discussion

Base Flow

Tables 8, 9, and 10 present the results from the base flow sampling effort. Only Lozier's Creek (Site 1), the Highlands Park Drain (Site 6), and the outlet (Site 5) had measurable discharge, or flow rate, during base flow sampling. Therefore, no base flow loading data are reported for Sites 2, 3, 3a, 3b, and 4.

TABLE 8. Chemical Characteristics of the Chapman Lakes' Inlet and Outlet Streams at Base and Storm Flows.

Site	Date	Timing	pH	Conductivity (:mhos)
1	10/12/00	Base	8.03	650
1	09/12/00	Storm	7.45	380
2	10/12/00	Base	8.02	670
2	09/12/00	Storm	7.68	530
3	10/12/00	Base	8.12	670
3	09/12/00	Storm	7.66	395
4	10/12/00	Base	7.2	400
4	09/12/00	Storm	6.92	200
5	10/12/00	Base	7.59	740
5	09/12/00	Storm	7.56	360
6	10/12/00	Base	7.95	720
6	09/12/00	Storm	**	**

** Sample not taken.

TABLE 9. Nutrient, Bacteria, and Sediment Concentration Data from the Chapman Lakes' Inlet and Outlet Streams.

Site	Date	Flow (cfs)	Timing	TKN (mg/l)	NH_3 (mg/l)	NO_3^- /NO_2^- (mg/l)	TP (mg/l)	OP (mg/l)	TSS (mg/l)	*E.coli* (col/100ml)
1	10/12/00	0.12	Base	<0.40	<0.10	5	0.03	<0.02	<1	100
1	09/12/00	22.1	Storm	1.4	<0.10	4.2	0.43	0.28	12	16000
2	10/12/00	*	Base	0.40	<0.10	4.2	0.03	0.02	4	8300
2	09/12/00	2.76	Storm	0.95	<0.10	4	0.29	0.07	7	14000
3	10/12/00	*	Base	<0.40	<0.10	3.2	0.05	0.03	<1	100
3a	10/12/00	*	Base	**	**	**	**	**	**	320
3b	10/12/00	*	Base	**	**	**	**	**	**	690
3	09/12/00	27.4	Storm	1.2	<0.10	2.84	0.4	0.18	34	23300
4	10/12/00	*	Base	2.4	<0.10	0.28	0.05	<0.02	5	50
4	09/12/00	1.4	Storm	1.8	<0.10	1.22	0.21	0.06	10	22300
5	10/12/00	2.1	Base	0.54	<0.10	0.74	0.05	<0.02	2	100
5	09/12/00	105.2	Storm	1.1	<0.10	1.58	0.21	<0.02	14	13300
6	10/12/00	0.2	Base	<0.40	<0.10	0.74	0.04	0.04	2	420
6	09/12/00	**	Storm	**	**	**	**	**	**	**

* Flow too low to measure.
** Sample not taken.
State Standards/Guidelines: NH_3 toxicity depends on temperature and pH.
NO_3^-+ NO_2^- not to exceed 10 mg/l.
E.coli not to exceed 235 col/100 ml in any one sample in a 30 day period.

TABLE 10. Nutrient and Sediment Loading Data from Chapman Lake Inlet and Outlet Streams at Base and Storm Flow.

Site	Date	Flow (cfs)	Timing	TKN Load (mg/s)	NH_3 Load (mg/s)	NO_3^- Load (mg/s)	TP Load (mg/s)	OP Load (mg/s)	TSS Load (mg/s)
1	09/12/00	22.1	Storm	876	†	2627	269	175	7505
2	09/12/00	2.76	Storm	74	†	312	23	5	547
3	09/12/00	27.4	Storm	931	†	2202	310	140	26364
4	09/12/00	1.4	Storm	71	†	48	8	2	396
5	09/12/00	6.58	Storm	3275	†	4704	625	†	41680
6	09/12/00	**	Storm	**	**	**	**	**	**
1	10/12/00	0.12	Base	†	†	17	0.1	†	†
2	10/12/00	*	Base	*	*	*	*	*	*
3	10/12/00	*	Base	*	*	*	*	*	*
4	10/12/00	*	Base	*	*	*	*	*	*
5	10/12/00	2.1	Base	32	†	44	1	†	119
6	10/12/00	0.2	Base	†	†	4	0.2	0.2	11

* Flow too low to measure.
** Sample not taken.
† Load not calculated because water sample carried concentration of nutrient that was below laboratory detection limits.

Values of pH in the Chapman Lakes' inlets and outlet were well within the range of 6-9 units established by the Indiana Administrative Code (327 IAC 2-1-6) for the protection of aquatic life. Table 8 also provides measurements of conductivity. Conductivity is a measure of the ionized or charged particles in the water. During low discharge, conductivity is higher than during storm water runoff (Table 8). This is because the water moves more slowly across or through ion-containing soils and substrates during base flow. Carbonate and other charged particles dissolve into the slow-moving water, thereby increasing conductivity measurements.

In general, nutrient and sediment concentrations were low in the inlets to the Chapman Lakes during base flow (Table 9). Nitrogen parameters (TKN, NH_3, and NO_3^-/NO_2^-) were often below laboratory detection limits. However, Crooked Creek (Site 3), the Island Park Drain (Site 4), and the Highlands Park Drain (Site 6) exhibited slightly elevated concentrations of total phosphorus during base flow. One-hundred percent of the total phosphorus measured in the Highlands Park Drain was bioavailable ortho-phosphorus. Additionally, base flow *E. coli* levels at Arrowhead Park (Site 2), Crooked Creek (Sites 3a and 3b), and the Highlands Park Drain (Site 6) exceeded the Indiana standard of 235 col/100ml for recreational water bodies.

During base flow, the Chapman Lake inlets contributed little loading of nutrients and sediment to the lake (Table 10) because many sites were not actively discharging to the lakes. Only Lozier's Creek (Site 1) and the Highlands Park Drain (Site 6) possessed measurable discharge rate. They contributed relatively small amounts of substances to the lakes per unit time compared to loading rates observed following the storm event.

While half of the *E. coli* base flow samples exceeded the single-sample state standard of 235 col/100mL, all but one (the Arrowhead Park Drain Site 2) of the sample concentrations were well within the typical range observed in Indiana streams/drains. The results obtained during the Chapman Lakes sampling were similar to the results reported in a study conducted by the U.S. Geological Survey (USGS, 2000) in the Upper Wabash River Watershed. Approximately 63% of the samples collected in that study exceeded the state single-sample standard compared to 50% of the base flow samples collected from the Chapman Lakes inlets.

The elevated concentration of *E. coli* found in the Arrowhead Park Drain (Site 2) is of concern. *E. coli* is used as an indicator organism to identify the potential for the presence of pathogenic organisms in a water sample. Pathogenic organisms can present a real threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. *E. coli* can come from the feces of any warm blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, and failing or improperly sited septic systems are common sources of *E. coli*. Given the location of the Arrowhead Park Drain subwatershed, all of these may have contributed to the elevated concentration noted during the base flow sampling effort. Dye testing of septic systems may be a useful way to determine if the septic systems upstream of the sampling point were responsible for the observed concentration.

Storm Flow

Tables 8, 9, and 10 also present the concentration and loading data for the storm event sampling. (Appendix 6 provides laboratory data sheets for the sampling.) Values of pH were within the normal range for streams in Indiana, and conductivity measurements were lower during storm water runoff due to ion dilution. Although nitrogen (TKN, NH_3, and NO_3^-/NO_2^-) levels were elevated relative to base flow, they were not high. Nitrate concentrations never exceeded the 10 mg/l designated as the human health standard (327 IAC 2-1-6). However, phosphorus and bacteria levels (*E. coli*) were extremely elevated for all sites during storm flow. High total and ortho-phosphorus concentrations were measured at Lozier's Creek (Site 1) and Crooked Creek (Site 3). *E. coli* levels exceeded state standards for recreational bodies at every site sampled. Greater than 20,000 col/100ml were measured for Crooked Creek (Site 3) and the Island Park Drain (Site 4).

The inlet streams contributed large amounts of nutrient and sediment to the Chapman Lakes during high flow events. Lozier's Creek (Site 1) and Crooked Creek (Site 3) added the largest amounts of pollutants to the lakes. Suspended solid loading and *E. coli* loading were greatest from Crooked Creek (Site 3), while ortho-phosphorus loading was most pronounced from Lozier's Creek (Site 1).

While all of the samples collected following the storm event exhibited extremely elevated *E. coli* concentrations, it is important to keep in mind the magnitude of the rain event after which samples were collected. This rain event was greater than a 100-year event. It is possible that even appropriately sited septic fields may not function as designed and leak contaminants to nearby waterways under such a storm. Few soils under such conditions could support a septic system. The only way to avoid such situations is to install a sanitary sewer system.

An additional interesting parameter to consider when evaluating water quality data is the N:P ratio of the nutrients being contributed to the system. Algae require a certain amount of nitrogen for every unit of phosphorus they uptake. For every seven units of nitrogen uptaken, algae need one unit of phosphorus. An evaluation of the N:P ratio can help indicate which nutrient is limiting algal growth and therefore which nutrient may be causing water quality problems. For this analysis, the fractions of dissolved nutrients were compared (i.e., nitrate+nitrite and ammonia: ortho-phosphorus). In general, dissolved nutrients are more bioavailable. During base flow, the N:P ratio of water contributed by all tributaries averaged about 96:1, while storm flow ratios averaged only about 5:1. In other words, during base flow the algae area not receiving enough phosphorus for each unit of nitrogen in order to grow. (i.e. phosphorus is the limiting nutrient.) During storm events, the watershed supplies plenty of phosphorus as evidenced by the 5:1 ratio. Thus, during storm events sufficient phosphorus is added to the lake to potentially create nuisance algae blooms. Watershed management efforts should focus on control of phosphorus input during stormwater runoff periods. Further evidence of the fact that phosphorus is the limiting nutrient in the lake is provided by the fact that very little ortho-phosphorus left the lake via the outlet (<0.02 mg/l during base flow).

Conclusions

In an effort to normalize the sediment, nutrient, and bacteria loading rates, the rates were divided by subwatershed size (Table 11). This information is useful for in prioritizing management efforts. Because only limited funds are available for management, efforts should focus on areas that contribute the most pollutants per acre. The Island Park Drain (Site 4) was not included in the analysis due to uncertainty regarding its watershed boundary. Site 5 was not included in the analysis as it represents the lakes' outlet. Due to data availability, storm flow loading was compared for Lozier's Creek (Site 1), the Arrowhead Park Drain (Site 2), and Crooked Creek (Site 3), while base flow measurements were compared for Lozier's Creek (Site 1) and the Highlands Park inlet (Site 6).

As shown in Table 11, Crooked Creek (Site 3) delivered the most TSS, TP, and *E. coli* per acre of watershed following a storm event. At base flow conditions, the Highlands Park inlet (Site 6) contributed substantial amounts of the pollutants despite having a relatively small watershed. Lozier's Creek (Site 1) should also be prioritized due to high concentration and loading of both total and ortho-phosphorus.

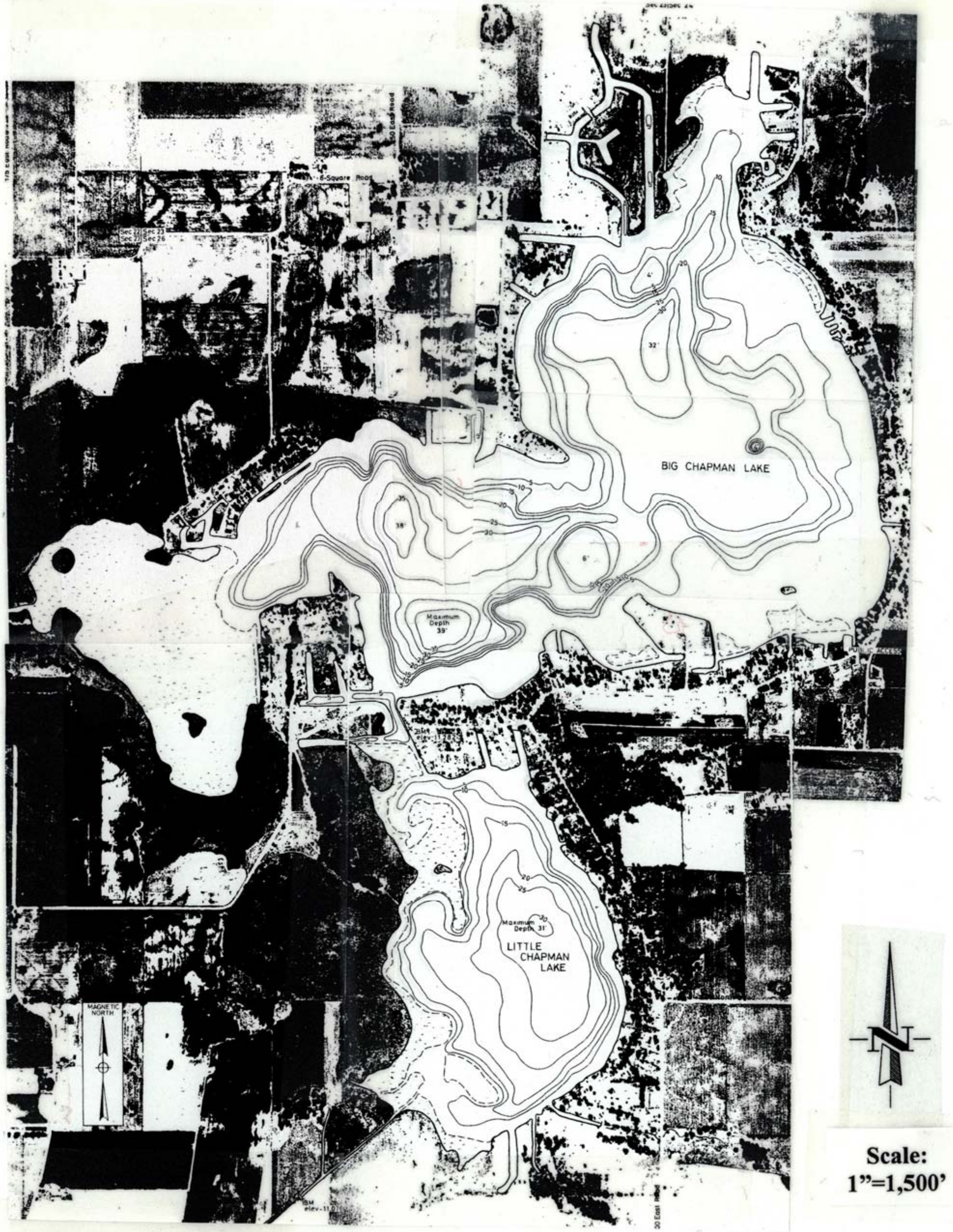
According to the water quality analysis of inflow streams to the Chapman Lakes, Crooked Creek (Site 3) should be of highest priority for management and restoration activities. This creek exhibited high concentrations of pollutants and elevated loads of phosphorus, sediment, and bacteria to the lakes. Additionally, management efforts should target the Highlands Park Inlet and Lozier's Creek in order to reduce the loading of nutrients and other pollutants, especially during runoff events.

TABLE 11. Sediment, Nutrient, and Bacteria Load in Inlet Streams Per Acre of Watershed.

Site	Watershed Size (ac)	Timing	TSS Load (mg/s-ac)	TP Load (mg/s-ac)	*E. coli* Load (col/s-ac)
1	839	Storm	9	0.3	11927
2	303	Storm	2	0.1	3609
3	775	Storm	34	0.4	23313
1	839	Base	0.004	0.0001	0.4
6	122	Base	0.09	0.001	19

LAKE MORPHOMETRY

Table 12 summarizes the Chapman Lakes' morphological characteristics. Big Chapman Lake is a two-lobed basin covering approximately 499 acres (202 ha). It has three deep basins with the deepest of the three (39 ft or 12 m) located in the southwest corner near the channel that connects Big Chapman Lake to Little Chapman Lake (Figure 32). Little Chapman Lake is a 139-acre (56-ha) basin, which is slightly curved in shape. Its deepest point (31 ft or 4.5 m) lies mid-lake. The shoreline development ratio is a measure of the development potential of a lake. It is calculated by dividing the shoreline length by the circumference of a circle that has the same area of the lake. A perfectly circular lake with the same area as Big Chapman Lake (499 acres or 202 ha) would have a circumference of 16,525 feet (5,038 m). The circumference of a circular lake



Source of Map: IDNR Division of Water

FIGURE 32. Bathymetric Map of the Chapman Lakes

equaling the area of Little Chapman Lake (139 acres or 56 ha) would be 8,723 ft (2,659 m). Dividing Big Chapman Lake's shoreline length by 16,525 feet yields a ratio of 2.9:1. The same operation for Little Chapman Lake gives a ratio of 3.1:1. These ratios are fairly high, but typical for this region. For example, on the Barbee Lakes chain, shoreline development ratios range from 1.5 to 3.84. Lakes with high shoreline development ratios have higher potential for development, and this potential is often realized. Greater development around a lake has obvious impacts on the health of the lake system.

TABLE 12. Morphological characteristics of Big and Little Chapman Lakes.

Big Chapman Lake	
Surface Area	499 acres (202 ha)
Volume	6257 ac-ft (7,721,103 m^3)
Maximum Depth	39 ft (12 m)
Mean Depth	12.5 ft (3.8 m)
Shoreline Length	48,241 ft (14,708 m)
Shoreline Development Ratio	2.9
Little Chapman Lake	
Surface Area	139 acres (56 ha)
Volume	1977 ac-ft (2,439,607 m^3)
Maximum Depth	31 ft (4.5 m)
Mean Depth	14.2 ft (4.3 m)
Shoreline Length	27,374 ft (8,346 m)
Shoreline Development Ratio	3.1

Depth-area and depth-volume curves were developed from the IDNR bathymetric map for Big and Little Chapman Lakes (Figures 33-36). Big Chapman Lake has a similar basin shape as other lakes in Kosciusko County; it possess a fairly large shallow area with over 50% of the lake being less than 10 feet (3.1 m) deep. In contrast, there is a fairly linear relationship between depth and area in Little Chapman Lake. Volume increases uniformly with depth in Big Chapman Lake until approximately 22 feet (6.5 m) where there is a sharp increase in depth per unit of volume. The sharp increase in depth per unit of volume in the lake's deeper water suggest that very little of Big Chapman Lake's volume is contained in the lake's deeper water. In Little Chapman Lake, volume increase uniformly with depth until approximately 25 feet (7.5 m).

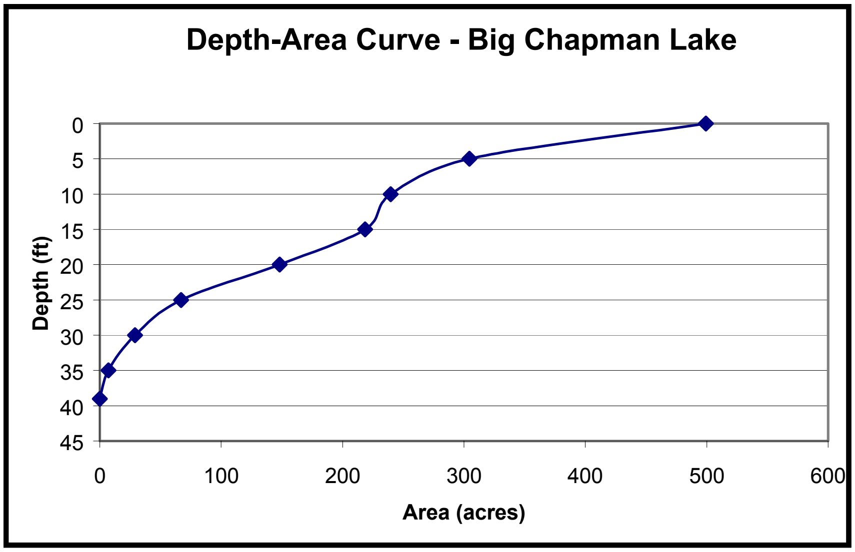


FIGURE 33. Depth-area curve for Big Chapman Lake.

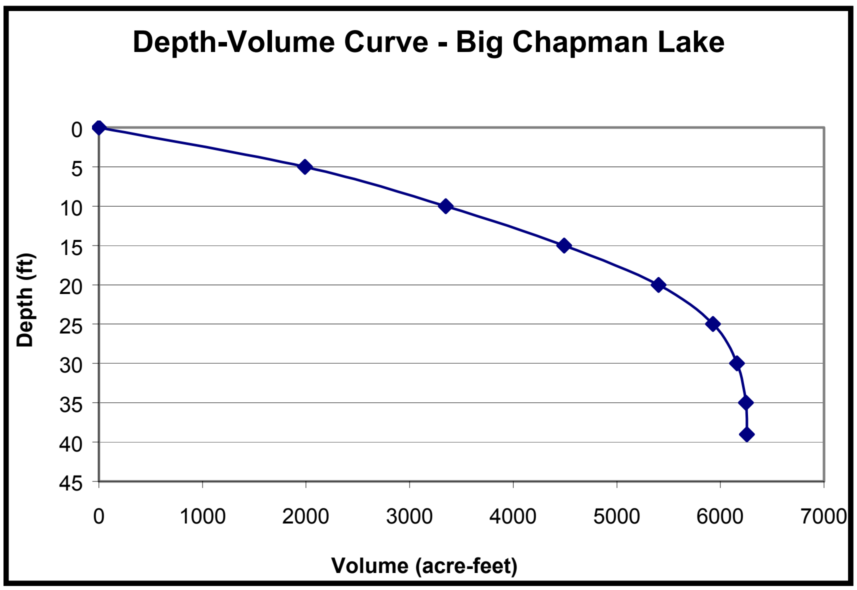


FIGURE 34. Depth-volume curve for Big Chapman Lake.

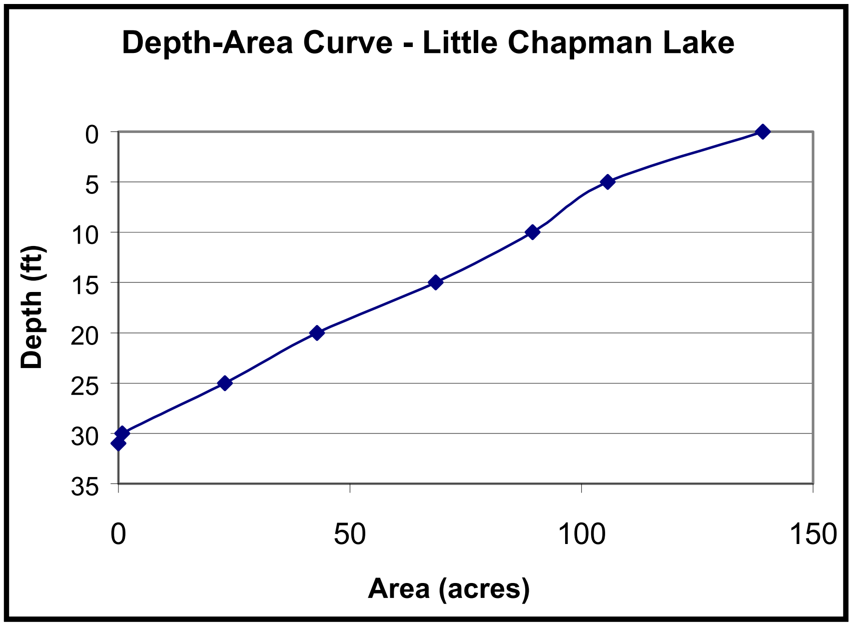


FIGURE 35. Depth-area curve for Little Chapman Lake.

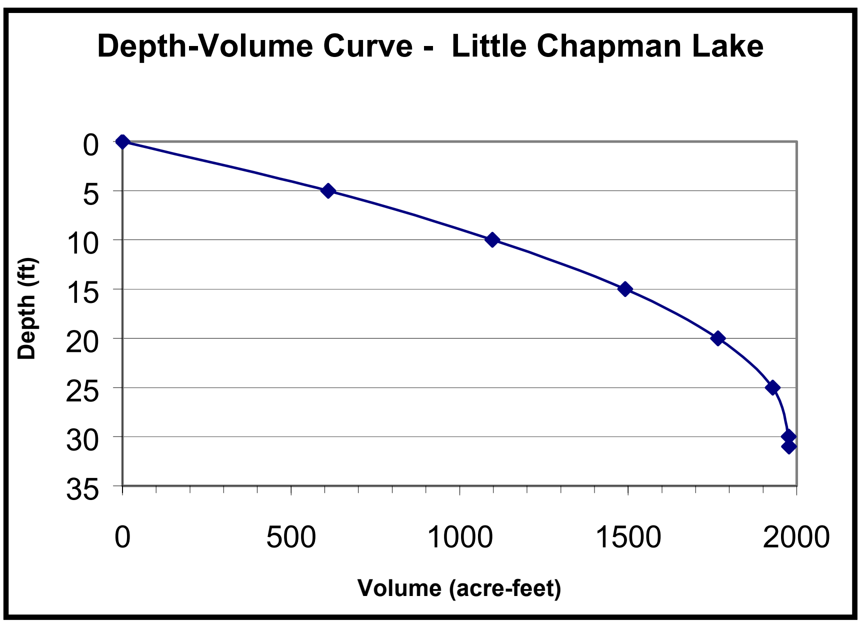


FIGURE 36. Depth-volume curve for Little Chapman Lake.

These curves are extremely useful in illustrating important relationships between depth, volume, and area. For example, if a particular rooted aquatic plant can grow in water up to ten feet deep, the potential habitat for this plant is approximately 260 acres (105 ha) in Big Chapman Lake and 42 acres (17 ha) in Little Chapman Lake. This suggests that rooted plants are capable of growing in over 50% of Big Chapman. Results from the macrophyte survey indicate that rooted plants cover considerably less that half the lake's surface area suggesting other factors may be limiting rooted plant growth in the lake. (See the Macrophyte Section for more details.) A lake's physical morphometry impacts the fish community structure as well. Predator fish species often require deep holes for refuge. The presence and size (volume) of such holes determines the number of predator fish species the lake is capable of supporting. (More detailed explanations of how the lake's morphometry impacts the lakes' biota and water chemistry are provided in the following sections.)

HISTORICAL WATER QUALITY

A search of published information on the Chapman Lakes revealed several lake assessments conducted by the Indiana Department of Environmental Management's (IDEM) Clean Lakes Program (CLP), records from volunteer lake monitors (also part of the Indiana Clean Lakes Program), and several Indiana Department of Natural Resources fisheries surveys. A citizen volunteer monitor still collects Secchi disk transparency on Big Chapman Lake.

Tables 13 and 14 present summaries of selected historic water quality parameters for Big and Little Chapman Lakes. (See Appendix 7 for a list of historic water quality parameters for Big Chapman Lake that includes the volunteer monitoring data.) The mean total phosphorus (TP) concentration in Big Chapman Lake decreased from 0.044 mg/L in 1992 (CLP, 1993) to 0.009 mg/L in 1995 (CLP, 1996) but then increased to 0.042 mg/L in 2000 (CLP, 2000). Figure 37 shows a steady decrease in TP concentrations until 1995, after which concentrations steadily increased. TP concentrations in the surface waters (epilimnion or 'epi') were lower than the TP concentrations on the deeper waters (hypolimnion or 'hypo'). A consistent pattern existed of lower concentrations in the surface waters and higher concentrations in the bottom waters. This suggests that phosphorus was being released from the sediments during stratified conditions and that the sediments are an important source of phosphorus to Big Chapman Lake.

The mean (epilimnetic + hypolimnetic) total phosphorus (TP) concentration in Little Chapman Lake increased from 0.03 mg/L in 1973 to 0.21 mg/L in 1989 and then decreased to 0.148 mg/L in 2000 (Figure 38). TP concentrations in the surface waters (epilimnion or 'epi') were much lower than the TP concentrations of the bottom waters (hypolimnion or 'hypo'). This suggests that phosphorus was being released from the sediments during stratified conditions. Few data were available for the analysis of historical phosphorus levels since no volunteer monitor records data for Little Chapman Lake.

TABLE 13. Selected Historic Data for Big Chapman Lake.

Sample Date	Secchi Disk (ft)	pH	Total Phosphorus (mg/L)	Alkalinity (mg/L)	Chlorophyll *a* (ug/L)	Data Source
06/04/64	12.0			145/138		McGinty, 1964
05/20/65		8.3		136		McGinty, 1965
07/04/73	10.0	0.01				IDEM, 1986
08/09/76		9.0/7.5		136.8/222.3		Shipman, 1976
06/10/91	9.0	8.1/7.9		188/239		Pearson, 1991
08/15/94	2.7	8.4/7.6	0.014/0.055		3.22	CLP, 1994
06/30/98	3.1	8.3 / 7.5	0.015/0.025		2.58	CLP, 1998
06/01/99	12.0	8.9/8.2		137/137		Pearson, 1999
08/07/00	2.3	8.4/7.6	0.03/0.082		1.77	Present Study

*epilimnetic values unless a hypolimnetic value is included after the /

TABLE 14. Selected Historic Data for Little Chapman Lake.

Sample Date	Secchi Disk (ft)	pH	Total Phosphorus (mg/L)	Alkalinity (mg/L)	Chlorophyll *a* (ug/L)	Data Source
07/23/69	4.8			112 / 190		Hudson, 1969
07/04/73	7.0		0.03			IDEM, 1986
08/16/76	4.5	9.0 / 7.0		154 / 240		Shipman, 1977
08/15/89	5.9	8.9 / 7.2	0.040 / 0.39	225 / 297		CLP, 1989
08/15/94	4.6	8.6 / 7.5	0.010* / 0.30	124 / 197	15.13	CLP, 1994
06/30/98	3.6	8.6 / 7.4	0.02 / 0.25	126 / 180	11.89	CLP, 1998
06/07/99	4.5	8.9 / 7.9		154 / 171		Pearson, 1999
08/07/00	4.3	8.6 / 7.5	0.079 / 0.217	126 / 182	6.56	CLP, 2000

*epilimnetic values unless a hypolimnetic value is included after the /

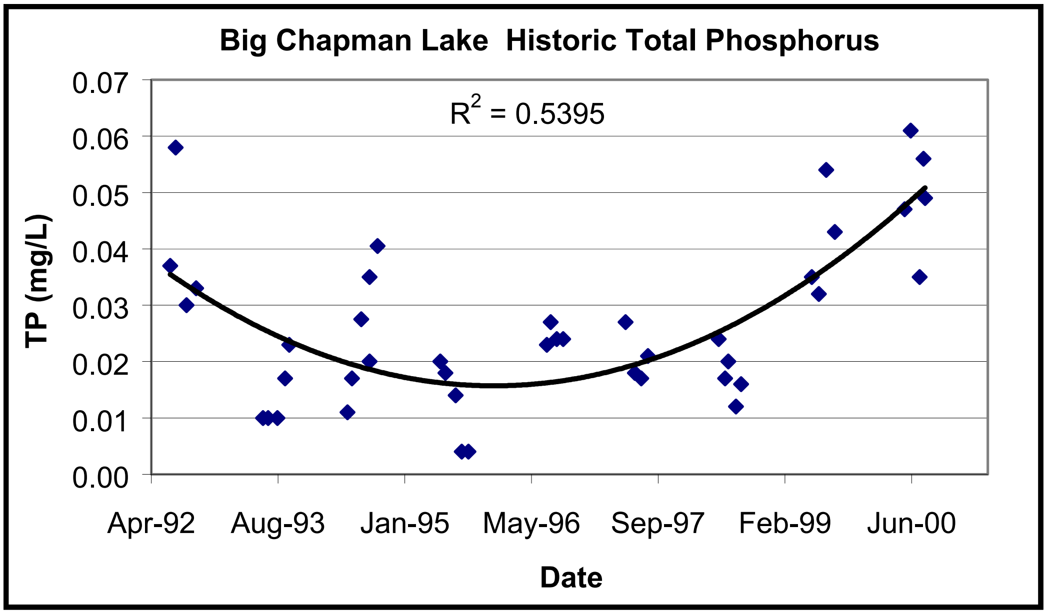


FIGURE 37. Historic total phosphorus data for Big Chapman Lake. The trendline has a surprisingly good fit (correlation coefficient = 0.54) which indicates that the trend is real.

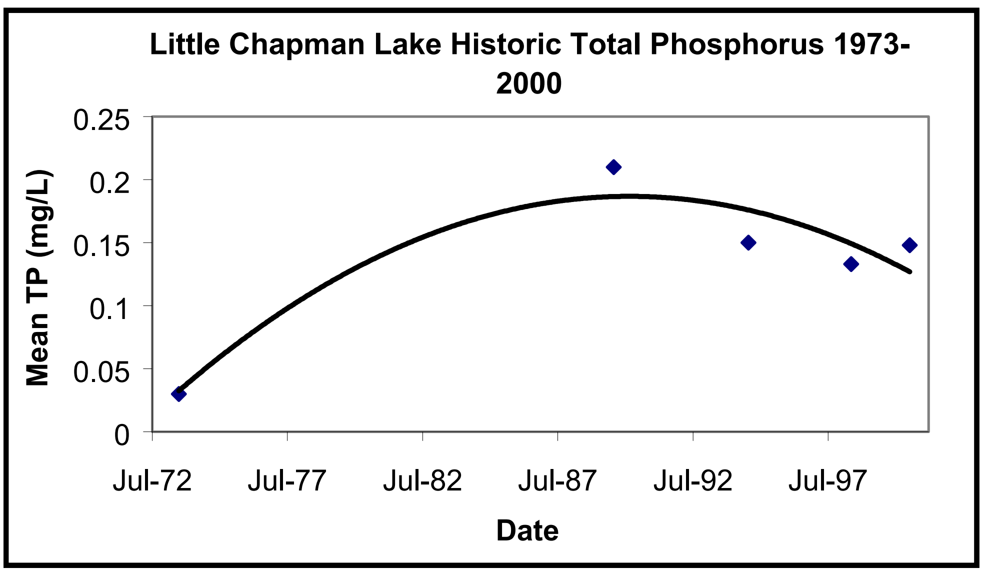


FIGURE 38. Historic total phosphorus concentrations measured in Little Chapman Lake.

In Big Chapman Lake, Secchi disk transparency was variable seasonally as expected and there was a very slight trend for decreasing transparency over time (Figure 39). A more pronounced trend of decreasing Secchi disk transparency is observed in the Little Chapman Lake data (Figure 40). This trend is indicative of increasing eutrophication. In Little Chapman Lake, Secchi disk transparency decreased from 4.8 feet (1.5 m) in 1969 to 4.3 feet (1.3 m) in 2000. The greatest transparency depth was 7.0 ft (2.1 m) in 1973 with the least amount of transparency (3.6ft or 1.1m) occurring in 1998.

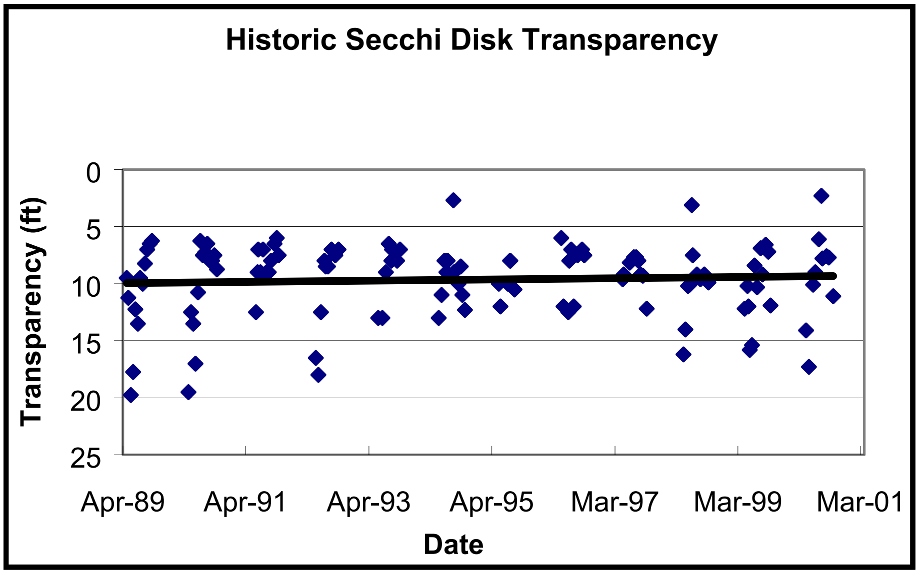


FIGURE 39. Historic Secchi disk transparency data for Big Chapman Lake with trendline.

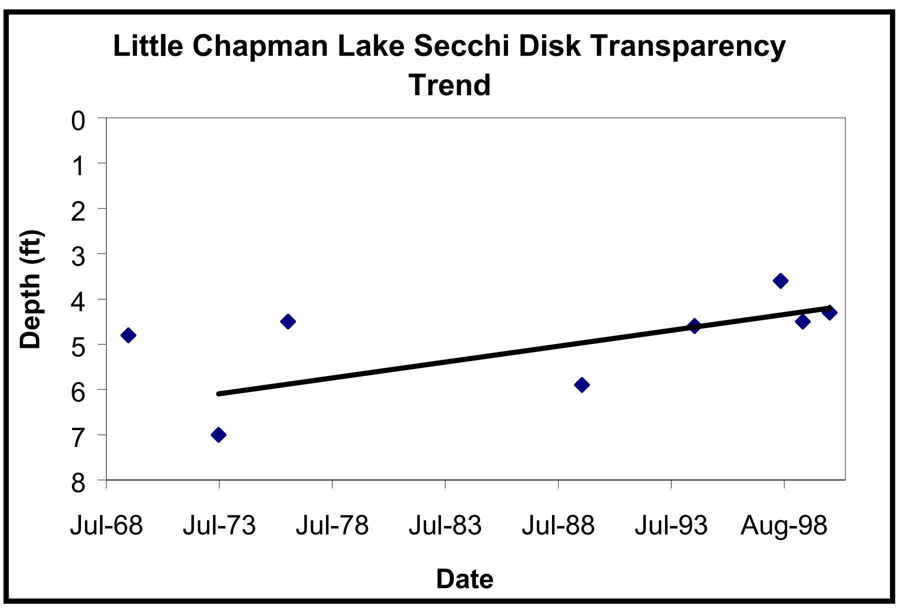


FIGURE 40. Historic Secchi disk transparency data for Little Chapman Lake with trendline.

Figures 41 and 42 present historical dissolved oxygen profiles for the lakes. Of particular note is the depth at which the water becomes devoid of oxygen (< 1.0 mg/L). This depth is generally lower in the early June measurements but measurements made later in the summer were invariably higher in the water column. It takes some length of time following the onset of stratification before the decomposition process consumes the oxygen in the hypolimnion. The

Big Chapman Lake data suggest that the lake's anoxia is consuming more of the lake (Figure 41). Note, for example, that the concentration of the 7-meter sample goes from 5 mg/L in 1994, to 1.5 mg/L in 1998, to less than 1 mg/L during our 2000 sampling. This trend further reinforces the notion that excessive biological productivity within the lake (and possibly organic matter discharges from the watershed) is an important source of biological oxygen demand (BOD) at the lake bottom.

Like Big Chapman Lake, Little Chapman Lake is thermally stratified during the summer months (Figure 42). The hypolimnion of the lake was anoxic for all the historical data found. The depth of initial anoxia ranged from 4 to 6 meters.

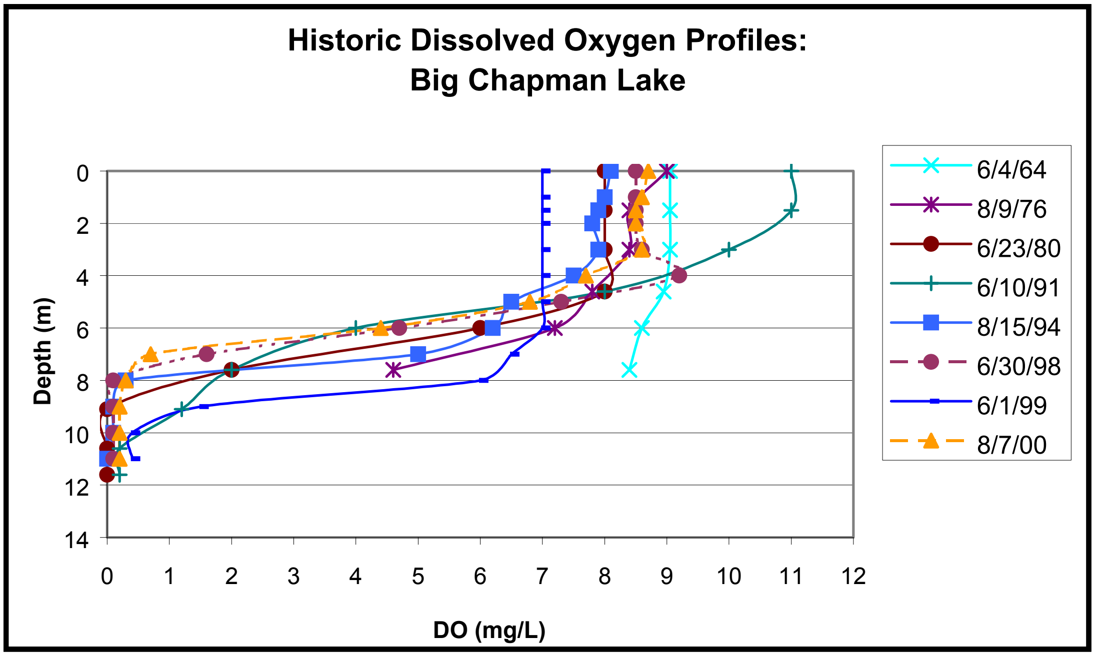


FIGURE 41. Historic dissolved oxygen profiles for Big Chapman Lake. Note, in particular, the point where concentrations fall below 1 mg/L.

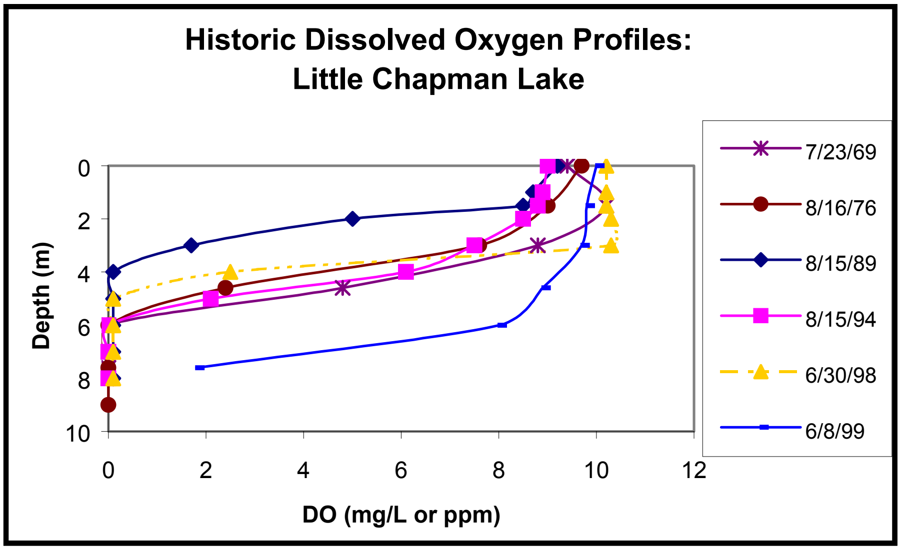


FIGURE 42. Historic dissolved oxygen profiles for Little Chapman Lake.

Comprehensive lake assessments were conducted on the Chapman Lakes in 1989, 1994, and 1998 under the auspices of the Indiana Clean Lakes Program. The results for these assessments are given in Tables 15-19. In Big Chapman Lake, the assessments show the lake possesses relatively low concentrations of phosphorus in the epilimnion and higher concentrations in the hypolimnion. Algal densities were moderate and were not dominated by blue-greens, the nuisance algae, during either of the samples. During the 1998 sampling, dissolved oxygen was supersaturated (>100%) at the five-foot level. This is an indication of substantial algal photosynthesis. Low dissolved oxygen in the hypolimnion prevented the oxidation of ammonia, produced as a by-product of bacterial decomposition of organic wastes. Because of this ammonia, potentially toxic to fish, was substantially higher in the hypolimnetic samples (0.502 & 0.307 mg/L) as compared to the epilimnetic samples (0.018 & 0.018 mg/L). The low dissolved oxygen and build-up of ammonia is symptomatic of the accumulation of excess organic matter on the lake's bottom.

Little Chapman Lake's historical Clean Lakes Program assessments show a similar trend of low concentrations of phosphorus in the epilimnion and higher concentrations in the hypolimnion, although the difference between the two is more pronounced. As indicated by the dissolved oxygen profile, anoxia in the hypolimnion was likely responsible for a release of phosphorus from the bottom sediments. The greater concentrations of phosphorus in the hypolimnion of Little Chapman Lake compared to Big Chapman Lake suggest greater internal phosphorus loading in Little Chapman Lake. The phosphorus loading model See Phosphorus Loading Section) support this. Higher concentrations of ammonia were also observed in Little Chapman Lake's hypolimnion compared to its epilimnion indicating that decomposition of organic wastes (dead algae and rooted plants) was occurring in Little Chapman Lake.

TABLE 15. Results of the 1994 Lake Water Quality Assessment of Big Chapman Lake.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.4	7.6	-
Alkalinity	126 mg/L	179 mg/L	-
Conductivity	370 μmhos	385 μmhos	-
Secchi Depth Transparency	2.7 meters	-	0
Light Transmission @ 3 ft.	54%	-	2
1% Light Level	23 feet	-	-
Total Phosphorous	0.014 mg/L	0.055 mg/L	1
Soluble Reactive Phosphorous	0	0	0
Nitrate-Nitrogen	0.022 mg/L	0.022 mg/L	0
Ammonia-Nitrogen	0.018 mg/L	0.502 mg/L	0
Organic Nitrogen	0.378 mg/L	0.590 mg/L	0
Oxygen Saturation @ 5 ft.	95%	-	0
% Water Column Oxic	85%	-	0
Plankton Density	8603 per L	-	2
Blue-Green Dominance	32%- No	-	0
Chlorophyll *a*	3.22 μg/L	-	-
		TSI Score	**5**

TABLE 16. Results of the 1998 Lake Water Quality Assessment of Big Chapman Lake.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.26	7.5	-
Alkalinity	123.9 mg/L	165.7 mg/L	-
Conductivity	380 μmhos	340 μmhos	-
Secchi Depth Transparency	3.1 meters	-	0
Light Transmission @ 3 ft.	55.59%	-	2
1% Light Level	20.3 feet	-	-
Total Phosphorous	0.015 mg/L	0.025 mg/L	0
Soluble Reactive Phosphorous	0.002 mg/L	0.003 mg/L	0
Nitrate-Nitrogen	0.022 mg/L	0.022 mg/L	0
Ammonia-Nitrogen	0.018 mg/L	0.307 mg/L	0
Organic Nitrogen	0.429 mg/L	0.104 mg/L	0
Oxygen Saturation @ 5 ft.	106%	-	0
% Water Column Oxic	63.63%	-	2
Plankton Density	17570 per L	-	3
Blue-Green Dominance	16% - No	-	0
Chlorophyll *a*	2.58 μg/L	-	-
		TSI Score	**7**

TABLE 17: Water Quality Characteristics of Little Chapman Lake, 1989.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.9	7.2	-
Alkalinity	225 mg/L	297 mg/L	-
Conductivity	790 µmhos	790 µmhos	-
Secchi Depth Transparency	1.8 meters	-	0
Light Transmission @ 3 ft.	30%	-	4
1% Light Level	14 feet	-	-
Total Phosphorous	0.040 mg/L	0.389 mg/L	4
Soluble Reactive Phosphorous	0.003 mg/L	0.340 mg/L	3
Nitrate-Nitrogen	2.314 mg/L	7.303 mg/L	4
Ammonia-Nitrogen	0.052 mg/L	3.582 mg/L	4
Organic Nitrogen	0.945 mg/L	0.833 mg/L	2
Oxygen Saturation @ 5ft.	108.3%	-	0
% Water Column Oxic	44.4%	-	3
Plankton Density	1150 per L	-	0
Blue-Green Dominance	42.1% - No	-	0
		TSI Score	**24**

TABLE 18: Water Quality Characteristics of Little Chapman Lake, 1994.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.6	7.5	-
Alkalinity	124 mg/L	196.5 mg/L	-
Conductivity	370 µmhos	370 µmhos	-
Secchi Depth Transparency	1.4 meters	-	6
Light Transmission @ 3 ft.	23%	-	4
1% Light Level	11 feet	-	-
Total Phosphorous	0 mg/L	0.3 mg/L	3
Soluble Reactive Phosphorous	0 mg/L	0.253 mg/L	3
Nitrate-Nitrogen	0.022 mg/L	0.022 mg/L	0
Ammonia-Nitrogen	0.018 mg/L	1.989 mg/L	4
Organic Nitrogen	0.425 mg/L	0.618 mg/L	1
Oxygen Saturation @ 5ft.	106%	-	0
% Water Column Oxic	65%	-	2
Plankton Density	18563 per L	-	3
Blue-Green Dominance	35.25% - No	-	0
Chlorophyll *a*	15.13 µg/L	-	-
		TSI Score	**26**

TABLE 19: Water Quality Characteristics of Little Chapman Lake, 1998.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.6	7.4	-
Alkalinity	125.5 mg/L	180 mg/L	-
Conductivity	370 µmhos	350 µmhos	-
Secchi Depth Transparency	1.1 meters	-	6
Light Transmission @ 3 ft.	27.54%	-	4
1% Light Level	9.6 feet	-	-
Total Phosphorous	0.02 mg/L	0.246 mg/L	3
Soluble Reactive Phosphorous	0.002 mg/L	0.219 mg/L	3
Nitrate-Nitrogen	0.022 mg/L	0.022 mg/L	0
Ammonia-Nitrogen	0.018 mg/L	0.073 mg/L	0
Organic Nitrogen	0.53 mg/L	1.265 mg/L	2
Oxygen Saturation @ 5ft.	128%	-	2
% Water Column Oxic	50%	-	2
Plankton Density	52715 per L	-	5
Blue-Green Dominance	52.84%- Yes	-	10
Chlorophyll *a*	11.89 µg/L	-	-
		TSI Score	**37**

Table 20 presents the Indiana TSI scores calculated from the lake sampling efforts in 1970's, 1988/1989, 1995, and 1998. As explained more fully in the In-Lake Sampling Section, ITSI are a measure of a lake's productivity or water quality. In general, higher ITSI scores indicate higher a level of eutrophication or poorer water quality. Big Chapman Lake ITSI scores appear to be decreasing over time. In other words, the Big Chapman Lake water quality is improving. The reverse is true with Little Chapman Lake; its ITSI scores have increased since the 1970's. Its water quality is deteriorating with time. A statistical trend analysis conducted by the Indiana Department of Environmental Management confirms this. Based on the lakes' ITSI scores, Big Chapman Lake's water quality has improved with time while Little Chapman Lake's water quality has declined. Comparing these trends to those observed in other lakes in the region (the Upper Wabash Basin), 27% of the lakes in the region (19% of the water surface acreage) showed some improvement in water quality. Conversely, 8% of the lakes in the region (3% of the acreage) exhibited a trend towards declining water quality (IDEM, 2000).

TABLE 20. Summary of Indiana TSI scores for the Chapman Lakes.

Year	1970's	1988/1989	1994	1998
Big Chapman	18	29	5	7
Little Chapman	25	24	26	37

IN-LAKE SAMPLING

Methods

The water sampling and analytical methods used for the Chapman Lakes were consistent with those used in IDEM's Indiana Clean Lakes Program and IDNR's Lake and River Enhancement Program. Water samples were collected for various parameters on August 7, 2000 from the surface waters (***epilimnion***) and from the bottom waters (***hypolimnion***) at the deepest point of each lake. These parameters include pH, alkalinity, conductivity, total suspended solids, total phosphorus, soluble reactive phosphorus, nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, and organic nitrogen.

In addition to these parameters, several other measurements of lake health were recorded. Secchi disk, light transmission, and oxygen saturation are single measurements made in the epilimnion. Chlorophyll was determined only for an epilimnetic sample. Dissolved oxygen and temperature were measured at one-meter intervals from the surface to the bottom. A tow to collect plankton was made from the 1% light level depth up to the water surface.

All sampling techniques and laboratory analytical methods were performed in accordance with procedures in *Standard Methods for the Examination of Water and* Wastewater, 19th Edition (APHA, 1995). Plankton counts were made using a standard Sedgewick-Rafter counting cell. Fifteen fields per cell were counted. Plankton identifications were made according to: Prescott (1982), Ward and Whipple (1959) and Whitford and Schumacher (1984).

The comprehensive evaluation of lakes requires collecting data on a number of different, and sometimes hard-to-understand, water quality parameters. Some of the more important parameters analyzed include:

Phosphorus Phosphorus is an essential plant nutrient, and the one that most often controls aquatic plant (algae and macrophyte) growth. It is found in fertilizers, human and animal wastes, and yard waste. There are few natural sources of phosphorus to lakes and there is no atmospheric (vapor) form of phosphorus. For this reason, phosphorus is often a ***limiting nutrient*** in lakes. This means that the relative scarcity of phosphorus in lakes may limit the ultimate growth and production of algae and rooted aquatic plants. Therefore, lake management efforts often focus on reducing phosphorus inputs to lakes because: (a) it can be managed and (b) reducing phosphorus can reduce algae production. Two common forms of phosphorus are:

Soluble reactive phosphorus (SRP) – SRP is dissolved phosphorus readily usable by algae. SRP is often in very low concentrations in lakes with dense algae populations where it is tied up in the algae themselves. SRP may be released from storage in sediments when dissolved oxygen is lacking.

Total phosphorus (TP) – TP includes dissolved and particulate phosphorus. TP concentrations greater than 0.03 mg/L (or 30 μg/L) can cause algal blooms.

Nitrogen Nitrogen is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80% of the air we breathe is nitrogen gas. This nitrogen can diffuse into water where it can be "fixed", or converted, by blue-green algae for their use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia.

Because of this, there is an abundant supply of available nitrogen to lakes. The three common forms of nitrogen are:

Nitrate (NO_3) – Nitrate is dissolved nitrogen that is converted to ammonia by algae. It is found in lakes when dissolved oxygen is present, usually in the surface waters.

Ammonium (NH_4) – Ammonium is dissolved nitrogen that is the preferred form for algae use. Bacteria produce ammonium as they decompose dead plant and animal matter. Ammonium is found where dissolved oxygen is lacking, often in the hypolimnia of eutrophic lakes.

Organic Nitrogen (Org N) – Organic nitrogen includes nitrogen found in plant and animal materials. It may be in dissolved or particulate form. In the analytical procedures, total Kjeldahl nitrogen (TKN) was analyzed. Organic nitrogen is TKN minus ammonia.

Dissolved Oxygen (D.O.) D.O. is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3-5 parts per million (ppm) of D.O. Cold-water fish such as trout and cisco generally require higher concentrations of D.O. than warm water fish such as bass or bluegill. D.O. affects a variety of chemical reactions in water. For example, the lack of D.O. near the bottom sediments may allow dissolved phosphorus (SRP) to be released from the sediments into the water. If less than 50% of a lake's water column has oxygen, greater hypolimnetic concentrations of SRP and ammonia are common as well. D.O. enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with D.O. Dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Secchi Disk Transparency Secchi disk transparency is the depth to which the black & white Secchi disk can be seen in the water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (for example, soil or dead leaves) may be introduced into the water by either runoff from the land or from sediments already on the bottom of the lake. Many processes may introduce sediments from runoff; examples include erosion from construction sites, agricultural lands and riverbanks. Bottom sediments may be resuspended by bottom feeding fish such as carp, or in shallow lakes, by motorboats or strong winds.

Light Transmission Similar to the Secchi disk transparency, this measurement uses a light meter (photocell) to determine the rate at which light transmission is diminished in the upper portion of the water column. Another important light transmission measurement is the 1% light level. The 1% light level is the water depth to which one percent of the surface light penetrates. This is considered the lower limit of algal growth.

Plankton Plankton are important members of the aquatic food web. They include algae (microscopic plants) and zooplankton (tiny shrimp-like animals that eat algae). Plankton density is determined by filtering water through a net having a very fine mesh (63 micron openings = 63/1000 millimeter). The plankton net is towed up through the water column from the one percent light level to the surface. Of the many different algal species present in the water, the blue-green algae are of particular interest. Blue-green algae are those that most often form nuisance blooms; their dominance in lakes may indicate poor water conditions.

Chlorophyll *a* The plant pigments of algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll *a* is by far the most dominant chlorophyll pigment and occurs in great abundance. Thus, chlorophyll *a* is often used as a direct estimate of algal biomass.

Results

Results of the assessment of Big Chapman Lake's water characteristics are included in Tables 21 and 22 and Figure 43. Results for Little Chapman Lake are presented in Table 23 and 24 and Figure 44.

TABLE 21. Water Quality Characteristics of Big Chapman Lake, 8/7/00.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.4	7.6	-
Alkalinity	120 mg/L	163 mg/L	-
Conductivity	380 μmhos	349.9 μmhos	-
Secchi Depth Transparency	2.3 meters	-	0
Light Transmission @ 3 ft.	50%	-	3
1% Light Level	23.5 feet	-	-
Total Phosphorous	0.03 mg/L	0.082 mg/L	2
Soluble Reactive Phosphorous	0.014 mg/L	0.011 mg/L	0
Nitrate-Nitrogen	0.004 mg/L	0.004 mg/L	0
Ammonia-Nitrogen	0.313 mg/L	0.460 mg/L	1
Organic Nitrogen	0.2 mg/L	1.225 mg/L	2
Oxygen Saturation @ 5ft.	104.4%	-	0
% Water Column Oxic	54%	-	2
Plankton Density	2203	-	0
Blue-Green Dominance	67% -Yes	-	10
Chlorophyll *a*	1.77 μg/L	-	-
		TSI Score	**20**

TABLE 22. Plankton Species Composition in Big Chapman Lake, 8/7/00.

SPECIES	ABUNDANCE (#/L)
Blue-Green Algae (Cyanophyta)	
Aphanizomenon	54
Anabaena	54
Chroococcus	27
Coelosphaerium	34
Lyngbya	7
Microcystis	1273
Oscillatroia	20
Misc. Blue-greens	14
Green Algae (Chlorophyta)	
Ulothrix	14
Misc. Green	20
Diatoms (Bacillariophyceae)	
Fragilaria	81
Synedra	135
Other Algae	
Ceratium	47
Dinobryon	14
Pediastrum	135
Misc. Protist	190
Zooplankton	
Bosmina	0.2
Calanoid Copepod	2.5
Cyclopoid Copepod	23.4
Nauplius Copepod	23.4
Daphnia	0.2
Rotifers	
Keratella	20
Polyarthra	14

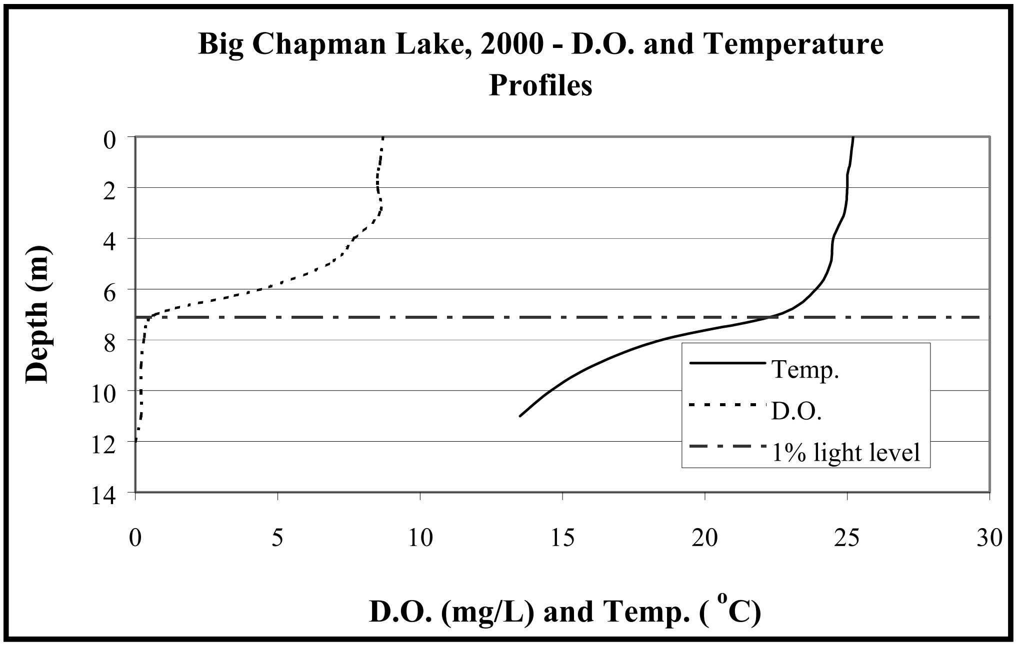


FIGURE 43. Dissolved oxygen and temperature profiles for Big Chapman Lake, 8/7/00.

TABLE 23. Water Quality Characteristics of Little Chapman Lake, 8/7/00.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.6	7.5	-
Alkalinity	126 mg/L	182 mg/L	-
Conductivity	368.8 µmhos	402.1 µmhos	-
Secchi Depth Transparency	1.3 meters	-	6
Light Transmission @ 3 ft.	45%	-	3
1% Light Level	13 feet	-	-
Total Phosphorous	0.079 mg/L	0.217 mg/L	3
Soluble Reactive Phosphorous	0.013 mg/L	0.173 mg/L	3
Nitrate-Nitrogen	0.013 mg/L	0.013 mg/L	0
Ammonia-Nitrogen	0.018 mg/L	1.251 mg/L	3
Organic Nitrogen	1.329 mg/L	2.063 mg/L	3
Oxygen Saturation @ 5ft.	102%	-	0
% Water Column Oxic	71%	-	1
Plankton Density	4231 per L	-	1
Blue-Green Dominance	52% - Yes	-	10
Chlorophyll *a*	6.56 µg/L	-	-
		TSI Score	**33**

TABLE 24. Plankton Species Composition in Little Chapman Lake, 8/7/00

SPECIES	ABUNDANCE (#/L)
Blue-Green Algae (Cyanophyta)	
Aphanizomenon	598
Anabaena	953
Chroococcus	61
Coelosphaerium	12
Lyngbya	195
Microcystis	354
Oscillatroia	12
Green Algae (Chlorophyta)	
Closterium	12
Pediastrum	98
Scendesmus	24
Ulothrix	598
Diatoms (Bacillariophyceae)	
Fragilaria	330
Synedra	379
Other Algae	
Ceratium	147
Misc. Protist	110
Zooplankton	
Calanoid Copepod	1.4
Cyclopoid Copepod	3.6
Nauplius Copepod	48.9
Misc. zooplankton	0.6
Rotifers	
Filinia	37
Kellicotia	12
Keratella	24
Polyarthra	24
Misc. Rotifer	110

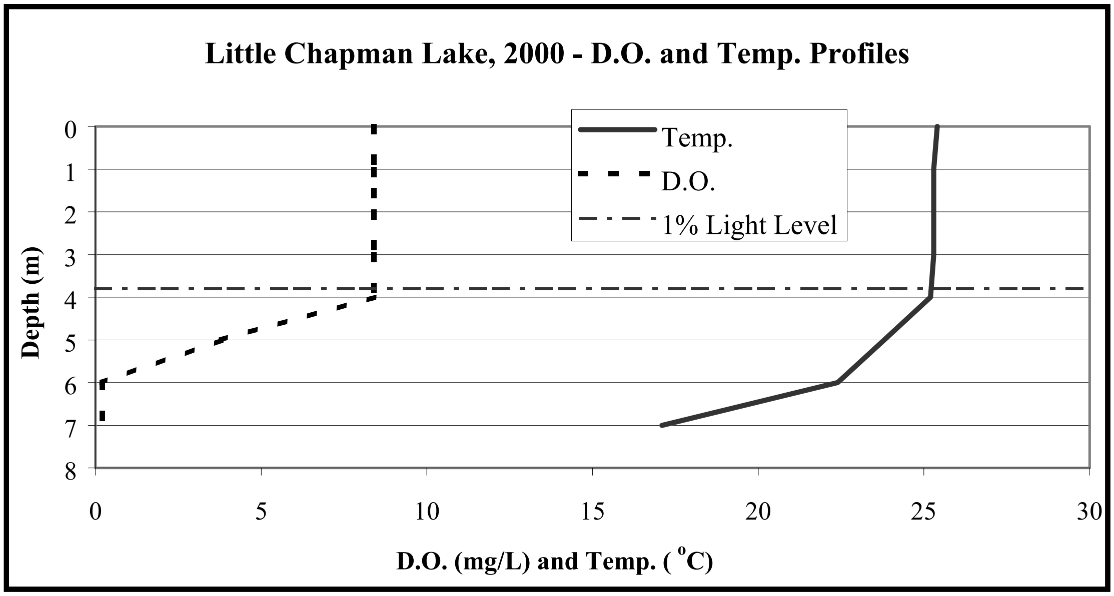


FIGURE 44. Dissolved oxygen and temperature profiles for Little Chapman Lake, 8/7/00.

Temperature and oxygen profiles for Big Chapman Lake show that the lake was stratified at the time of sampling (Figure 43). During thermal stratification, the bottom waters (***hypolimnion***) of the lake are isolated from the well-mixed surface waters (***epilimnion***) by temperature-induced density differences. The boundary between these two zones, where temperature changes most rapidly with depth is called the ***metalimnion***. At the time of sampling, the epilimnion was confined to the upper 6 meters of water. This rather deep 'mixing zone' suggests that the lake is influenced strongly by winds. The sharp decline in temperature between 6 and about 8 meters defines the metalimnion or transition zone. From 8 meters to 11 meters, the temperature decline is less sharp. This tapering off blurs the distinct stratification of the metalimnion and the hypolimnion. For the purposes of this report, the lower 4 meters will be referred to as the hypolimnion.

Big Chapman Lake has a typical oxygen profile. The epilimnion is nearly saturated with oxygen but concentrations increase to 104.4% saturation at 5 feet. This phenomenon is known as a metalimnetic oxygen maximum. It is likely due to a high density of photosynthesizing algae positioned in the lower epilimnion/upper metalimnion boundary where there is still adequate light and where they have access to more plentiful nutrients in the hypolimnion. Below this point, oxygen concentrations decline steadily as bacteria decompose algae as they settle down through the water column. The water becomes anoxic (devoid of oxygen) at around 7 meters, which corresponds with the temperature profile's hypolimnetic boundary.

Temperature and oxygen profiles for Little Chapman Lake show that the lake was stratified at the time of sampling (Figure 44). At the time of sampling, the epilimnion was confined to the upper 4 meters of water. The decline in temperature between 4 and about 7 meters defines the metalimnion. The hypolimnion is not well-defined by the temperature profile.

Little Chapman Lake has a common oxygen profile for relatively productive lakes. The epilimnion is nearly saturated with oxygen with concentrations of 102% saturation at 5 feet. (This is a slight metalimnetic oxygen maximum described above.) The oxygen profile maintains saturation until the stratified conditions at 4 meters. Below this point, oxygen concentrations decline rapidly, likely due to biochemical oxygen demand and chemical oxygen demand in the deeper water. The remaining oxygen is consumed by 6 meters, creating completely anoxic conditions.

Water quality data for the lakes are presented in Tables 21 and 23. Phosphorus and nitrogen are the primary plant nutrients in lakes. Concentrations of these nutrients are relatively low in the surface waters of the lake, due likely to uptake by algae. When the algae die and settle to the bottom sediments, nutrients are relocated to the hypolimnion. Higher concentrations of phosphorus in the hypolimnion may also result from chemical processes occurring at the sediment/water interface.

In Big Chapman Lake, total phosphorus concentrations were elevated in the hypolimnion but there was no similar increase in soluble phosphorus. There are two possible explanations for this: 1) soluble phosphorus was liberated from the sediments due to the anoxic, chemically reducing conditions there but this phosphorus was taken up by the deep water plankton in the upper hypolimnion, or 2) the higher phosphorus concentrations are due primarily to plankton and other organic matter that has settled out of the surface waters into the hypolimnion.

Nitrate, an oxidized form of inorganic nitrogen, was found in very low concentrations in the August 7 samples. However ammonia, a reduced form of inorganic nitrogen, was found in elevated concentrations. In the presence of oxygen, ammonia is rapidly oxidized to nitrate. The high epilimnetic ammonia concentrations indicate that either a recent runoff event delivered ammonia-laden water to the lake, or significant decomposition of organic matter was occurring. The elevated ammonia concentrations in the hypolimnion were expected, due to the anoxia and likely elevated decomposition rates.

In Little Chapman Lake, higher concentrations of phosphorus (total and soluble) in the hypolimnion indicate that phosphorus is being liberated from the sediments due to the anoxic, chemically reducing conditions in the hypolimnion. There is an undetectable amount of soluble reactive phosphorus in the epilimnion because this dissolved form is rapidly taken up and used by algae and other plants. Because ammonia is a by-product of the decomposition of organic matter, ammonia concentrations are also higher in the hypolimnion where decomposition rates are high and where ammonia is not oxidized.

Alkalinity is a measure of the water's ability to resist change in pH, or acid content. It is also referred to as acid neutralizing capacity or buffering capacity. This buffering action is important because it ensures a relatively constant chemical and biological environment in lakes. Alkalinity is determined largely by the availability and chemistry of carbonate in water. Sources of carbonate to natural waters include limestone (calcium carbonate) and carbon dioxide. The high alkalinity concentrations indicate that both Big and Little Chapman Lakes are well-buffered systems.

Values of pH are slightly higher in the epilimnion of both lakes where the process of photosynthesis consumes carbon dioxide, a weak acid. The lack of photosynthesis in the hypolimnion, and the liberation of carbon dioxide by respiring bacteria keep pH levels lower in the hypolimnion. The lakes' conductivity values, a measure of dissolved ions, are within the normal range for Indiana lakes.

In Big Chapman Lake, Secchi disk transparency was only 2.3 meters and 50% of the incident light had been extinguished by the depth of 3 feet. Low algal concentrations indicate that this reduction in transparency was due to non-algal turbidity. The 1% light level, which limnologists use to determine the lower limit where photosynthesis can occur, extended to a depth of 23.5 feet (7.1 meters) in Big Chapman Lake. This rather deep 1% light depth results from the low plankton concentrations. (Few plankton are available to block the penetrating light.)

By referring to the depth-volume curve in Figure 34, we can determine that approximately 93% of the water volume in the lake has sufficient light to support algae. With this much light availability and sufficient nutrients, robust algal densities were expected in Big Chapman Lake. However, algal density was a relatively low 2,203 organisms per liter. The plankton enumeration revealed a rather high density of large zooplankton. Large zooplankton prey on algae, which may account for the low algal density. Alternatively, the August 7 sampling may have coincided with an algal die-off. The low algal density along with the elevated epilimnetic ammonia concentrations and high non-soluble phosphorus concentrations in the hypolimnion supports this hypothesis. Algae populations are cyclical during the summer growing season and may undergo several bloom and die-off periods.

In contrast, the 1% light level in Little Chapman Lake extended to a depth of 13 feet (4.0 meters). This 1% light depth results from the high plankton concentrations, which is also supported by the high chlorophyll *a* concentrations of 6.56 μg/L. Based on the depth-volume curve in Figure 36, approximately 70% of the water volume in the lake has sufficient light to support algae. When the photic zone occupies this much of the lake volume and sufficient nutrients are present, high algal production is inevitable.

The plankton density in Little Chapman Lake was approximately twice the density found in Big Chapman Lake at the time of sampling, however the density is low in comparison to other area lakes. Blue-green algae, the algal group most often associated with nuisance blooms, accounted for as much as 52% of the total number of cells in the sample.

Algae like most green plants depend on light and several important nutrients for their growth. If any of the essentials needed for growth are in limited supply, algal growth will not achieve its maximum rate. The material in least supply is known as growth limiting. The ratio of nitrogen and phosphorus in plant tissue is 7 parts nitrogen to 1 part phosphorus. In both Big and Little Chapman Lakes, the ratio of total nitrogen to total phosphorus in the surface water where growth can occur is approximately 17:1. This is indicative of a phosphorus-limited environment.

Discussion

The interpretation of a comprehensive set of water quality data can be quite complicated. Often, attention is directed at the important plant nutrients (phosphorus and nitrogen) and to water transparency (Secchi disk) since dense algal blooms and poor transparency greatly affect the health and use of lakes.

To more fully understand the water quality data, it is useful to compare data from the lake in question to standards, if they exist, to other lakes, or to criteria that most limnologists agree upon. Because there are no nutrient standards for Indiana lakes, the Chapman Lakes results are compared below with data from other lakes and with generally accepted criteria.

Comparison With Vollenweider's Data

Results of studies conducted by Richard Vollenweider in the 1970's are often used as guidelines for evaluating concentrations of water quality parameters. His results are given in Table 25 below. Vollenweider relates the concentrations of selected water quality parameters to a lake's *trophic state*. The trophic state of a lake refers to its overall level of nutrition or biological productivity. Trophic categories include: *oligotrophic, mesotrophic, eutrophic* and *hypereutrophic*. Lake conditions characteristic of these trophic states are:

Oligotrophic - lack of plant nutrients keep productivity low; lake contains oxygen at all depths; clear water, deeper lakes can support trout.

Mesotrophic - moderate plant productivity; hypolimnion may lack oxygen in summer; moderately clear water, warm water fisheries only - bass and perch may dominate.

Eutrophic - contains excess nutrients; blue-green algae dominate during summer; algae scums are probable at times; hypolimnion lacks oxygen in summer; poor transparency; rooted macrophyte problems may be evident.

Hypereutrophic - algal scums dominate in summer; few macrophytes; no oxygen in hypolimnion; fish kills possible in summer and under winter ice.

The units in the table are either milligrams per liter (mg/L) or micrograms per liter (µg/L). One mg/L is equivalent to one part per million (PPM) while one microgram per liter is equivalent to one part per billion (PPB). These are only guidelines; similar concentrations in a particular lake may not cause problems if something else is limiting the growth of algae or rooted plants.

TABLE 25. Mean values of some water quality parameters and their relationship to lake production (after Vollenweider, 1975).

PARAMETER	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Total Phosphorus (mg/L or PPM)	0.008	0.027 ★	0.084 #	>0.750
Total Nitrogen (mg/L or PPM)	0.661	0.753 ★	1.875 #	-
Chlorophyll *a* (µg/L or PPB)	1.7 ★	4.7 #	14.3	-

The values for Big Chapman Lake are indicated by the asterisk (⋆) and the values for Little Chapman Lake are indicated by the number symbol (#) in the table above. For Big Chapman Lake, both total phosphorus and total nitrogen mean concentrations match the mean concentration for mesotrophic lakes. The chlorophyll *a* concentration, however, satisfies the mean for oligotrophic lakes. For Little Chapman Lake, the total phosphorus concentration exceeds the mean concentration for eutrophic lakes while the total nitrogen concentration falls within the range of concentrations for eutrophic lakes. The chlorophyll *a* concentration exceeded the mean for mesotrophic lakes.

Comparison With Other Indiana Lakes

The Chapman Lakes results can also be compared to other Indiana lakes. Table 26 presents data from 355 Indiana lakes collected during July and August 1994-98 under the Indiana Clean Lakes Program. The set of data summarized in the table represent mean values of epilimnetic and hypolimnetic samples for each of the 355 lakes. It should be noted that a wide variety of conditions, including geography, morphometry, time of year, and watershed characteristics, could influence the water quality of lakes. Thus, it is difficult to predict or even explain the reasons for the water quality of a given lake.

TABLE 26. Water Quality Characteristics of 355 Indiana Lakes Sampled From 1994 thru 1998 by the Indiana Clean Lakes Program. Means of epilimnion and hypolimnion samples were used. Values marked with (⋆) are below instrument detection levels.

	Secchi Disk (m)	NO_3 (mg/L)	NH_4 (mg/L)	TKN (mg/L)	Total Phos (mg/L)	SRP (mg/L)	Chl. *a* (μg/L)
Median	1.8	0.025	0.472	1.161	0.097	0.033	5.33
Maximum	9.2	9.303	11.248	13.794	4.894	0.782	230.9
Minimum	0.1	0.022	0.018	0.230	0.001	0.001	0
Big Chapman	**2.3**	**0.013⋆**	**0.387**	**1.099**	**0.056**	**0.0125**	**1.77**
Little Chapman	**1.3**	**0.013⋆**	**0.628**	**2.324**	**0.148**	**1.696**	**6.56**

All the parameters measured at Big Chapman Lake fall below the median values measured for the set of Indiana lakes. This indicates that Big Chapman Lake had better overall water quality than most Indiana lakes at the time of the August 7, 2000 sampling. The Little Chapman Lake results for ammonia, total Kjeldahl nitrogen, total phosphorus, and soluble reactive phosphorus all exceed the median values for the Indiana lakes included in the table. Thus, water quality in Little Chapman Lake is worse than most Indiana lakes at the time of sampling.

Using a Trophic State Index

In addition to simple comparisons to other lakes, lake water quality data can be evaluated through the use of a trophic state index or TSI. Indiana and many other states use a trophic state index (TSI) to help evaluate water quality data. A TSI condenses water quality data into a single, numerical index. Different index (or eutrophy) points are assigned for various water quality concentrations. The index total, or TSI, is the sum of individual eutrophy points for a lake.

The Indiana TSI

The Indiana TSI (ITSI) was developed by the Indiana Stream Pollution Control Board and published in 1986 (IDEM, 1986). The original ITSI differed slightly from the one in use today. Today's ITSI uses ten different water quality parameters to calculate a score. Table 27 shows the point values assigned for each parameter.

TABLE 27. The Indiana Trophic State Index.

Parameter and Range			Eutrophy Points
I.	Total Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
II.	Soluble Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
III.	Organic Nitrogen (ppm)		
	A.	At least 0.5	1
	B.	0.6 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
IV.	Nitrate (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
V.	Ammonia (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.5	2
	C.	0.6 to 0.9	3
	D.	1.0 or more	4
VI.	Dissolved Oxygen: Percent Saturation at 5 feet from surface		
	A.	114% or less	0
	B.	115% 50 119%	1
	C.	120% to 129%	2

D.	130% to 149%	3
E.	150% or more	4

VII. Dissolved Oxygen:
Percent of measured water column with at least 0.1 ppm dissolved oxygen

A.	28% or less	4
B.	29% to 49%	3
C.	50% to 65%	2
D.	66% to 75%	1
E.	76% 100%	0

VIII. Light Penetration (Secchi Disk)

A.	Five feet or under	6

IX. Light Transmission (Photocell) : Percent of light transmission at a depth of 3 feet

A.	0 to 30%	4
B.	31% to 50%	3
C.	51% to 70%	2
D.	71% and up	0

X. Total Plankton per liter of water sampled from a single vertical tow between the 1% light level and the surface:

A.	less than 3,000 organisms/L	0
B.	3,000 - 6,000 organisms/L	1
C.	6,001 - 16,000 organisms/L	2
D.	16,001 - 26,000 organisms/L	3
E.	26,001 - 36,000 organisms/L	4
F.	36,001 - 60,000 organisms/L	5
G.	60,001 - 95,000 organisms/L	10
H.	95,001 - 150,000 organisms/L	15
I.	150,001 - 5000,000 organisms/L	20
J.	greater than 500,000 organisms/L	25
K.	Blue-Green Dominance: additional points	10

Values for each water quality parameter are totaled to obtain an ITSI score. Based on this score, lakes are then placed into one of five categories:

TSI Total	Water Quality Classification
0-15	Oligotrophic
16-31	Mesotrophic
32-46	Eutrophic
47-75	Hypereutrophic
*	Dystrophic

Four of these categories correspond to the qualitative lake productivity categories. The fifth category, dystrophic, is for lakes that possess high nutrient concentration but have limited rooted plant and algal productivity (IDEM, 2000). A rising TSI score for a particular lake from one year to the next indicates that water quality is worsening while a lower TSI score indicates improved conditions. However, natural factors such as climate variation can cause changes in TSI score that do not necessarily indicate a long-term change in lake condition.

The Indiana Trophic State Index value calculated for Big Chapman Lake is 20 (Table 21). This value falls within the mesotrophic range. This conclusion is consistent with the results obtained from the comparison of the Big Chapman Lake data to Vollenweider's data (Table 25). It is also consistent with the physical appearance of the lake. Big Chapman Lake does not support an extensive rooted plant population throughout its shallow areas. The moderate level of rooted plant productivity in the lake is similar to the qualitative description for mesotrophic lakes (See page 73).

Because the ITSI captures one snapshot of a lake in time, using the ITSI to track trends in lake productivity may be the best use of the ITSI. Table 21 presents historical ITSI scores for Big Chapman Lake. Historical scores show a trend toward decreasing ITSI scores or improving water quality. The current ITSI score of 20 appears to reverse that trend. It should be noted, though, that half of the 20 points came from a single parameters: blue-green algae dominance. The Indiana TSI has been criticized for its heavy reliance of algae compared to the weight given to transparency and nutrient parameters. (Thirty-five of the possible 75 points can come from the plankton category.) Thus, it is important to consider the lake's biological and chemical parameters within the context of several evaluation methods such as those presented in this document. Taken collectively, the chemical parameters of Big Chapman Lake are low in general but high enough to warrant concern that water quality conditions could change for the worse. An ITSI score of 20, which places Big Chapman Lake at the low end of the mesotrophic category, supports this theory.

The Indiana Trophic State Index value calculated for Little Chapman Lake is 33 (Table 23). This places Little Chapman Lake in the eutrophic range. As with Big Chapman Lake, this conclusion is consistent with the results obtained from the comparison to Vollenweider's data (Table 25) and the physical appearance of the lake. Little Chapman Lake supports a more extensive rooted plant population than Big Chapman Lake. No large change in ITSI score (10+ points) was observed in Little Chapman Lake. The score of 33 is roughly equal to one of 37 (the 1998 score) given the natural variability in climatic and other environmental factors.

Using the ITSI to compare the Chapman Lakes to other lakes in the region, Big Chapman Lake's water quality is slightly better than most lakes in the region while Little Chapman Lake's water quality is worse than most lakes in the region. Based on data collected by the Clean Lakes Program 1998 assessment, approximately 12% of the lakes in the Upper Wabash Basin (which includes most of Kosciusko County) were classified as oligotrophic (IDEM, 2000). Another 35% rated as mesotrophic. Forty five percent fell in the eutrophic category, while 8% fell in the hypereutrophic category. This evaluation is consistent with comparing raw data scores for the lakes to those for all lakes in Indiana (Table 26).

The Carlson TSI

Because the Indiana TSI has not been statistically validated and because of its heavy reliance of algal parameters, the Carlson TSI may be more appropriate to use in evaluating Indiana lake data. Developed by Bob Carlson (1977), the Carlson TSI is the most widely used and accepted TSI. Carlson analyzed summertime total phosphorus, chlorophyll *a*, and Secchi disk transparency data for numerous lakes and found statistically significant relationships among the three parameters. He developed mathematical equations for these relationships, and these relationships form the basis for the Carlson TSI. Using this index, a TSI value can be generated by one of three measurements: Secchi disk transparency, chlorophyll *a* or total phosphorus. Data for one parameter can also be used to predict a value for another. The TSI values range from 0 to 100. Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass (Figure 45).

As a further aid in interpreting TSI results, Carlson's scale is divided into four lake productivity categories: oligotrophic (least productive), mesotrophic (moderately productive), eutrophic (very productive) and hypereutrophic (extremely productive).

Using Carlson's index, a lake with a summer time Secchi disk depth of 1 meter (3.3 feet) would have a TSI of 60 points (located in line with the 1 meter (3.3 feet)). This lake would be in the mesotrophic category. Because the index was constructed using relationships among transparency, chlorophyll, and total phosphorus, a lake having a Secchi disk depth of 1 meter (3.3 feet) would also be expected to have 20 μg/L chlorophyll and 43 μg/L total phosphorus.

Not all lakes have the same relationship between transparency, chlorophyll and total phosphorus as Carlson's lakes do. Other factors such as high suspended sediments or heavy predation of algae by zooplankton may keep chlorophyll concentrations lower than might be otherwise expected from the total phosphorus or chlorophyll concentrations. High suspended sediments would also make transparency worse than otherwise predicted by Carlson's index.

It is also useful to compare the actual trophic state points for a particular lake from one year to the next to detect any trends in changing water quality. While climate and other natural events will cause some variation in water quality over time (possibly 5-10 trophic points), larger point changes may indicate important changes in lake quality.

CARLSON'S TROPHIC STATE INDEX

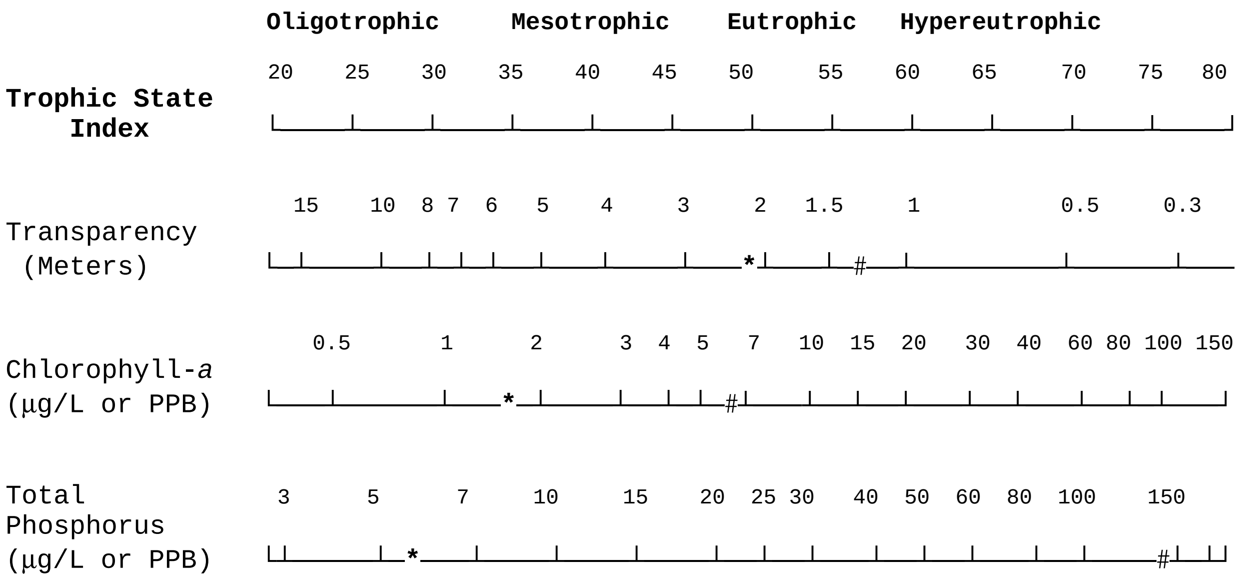


FIGURE 45. Carlson's Trophic State Index with Big Chapman Lake values indicated by (⋆) and Little Chapman Lake values indicated by (#).

Analysis of the Big Chapman chlorophyll *a* and total phosphorus data using Carlson's TSI show that these parameters fall near the oligotrophic/mesotrphic categories border (see asterisks in Figure 45). The transparency data registers in the low eutrophic range. These results are similar to those obtained when the data was scored with the Indiana TSI and when the data was compared to Vollenweider's data. It supports the theory that water quality is fairly good in Big Chapman Lake but the lake has little room to absorb a further increase in nutrients and sediments. Such an increase may immediately translate to nuisance algal blooms and increases in rooted plant populations.

For Little Chapman Lake, the transparency and chlorophyll *a* data fall in the eutrophic category using Carlson's TSI. The phosphorus data register in the higher eutrophic range, primarily due to the high internal loading of phosphorus from the lake's bottom sediments. These results are consistent with those obtained when the data scored with the Indiana TSI and when the data was compared to Vollenweider's data.

FISHERIES

A fisheries survey was not conducted as a part of the diagnostic study. The Indiana Department of Natural Resources (IDNR) fisheries biologists performed complete fisheries surveys on both lakes in 1999. Below is a summary of this survey and other historical fisheries surveys on the lakes.

Several studies have been conducted over the past 80 years to assess the fisheries of both Big and Little Chapman Lakes. Both lakes were mapped by Indiana University in 1922. In 1942, William Ricker (1942) sampled bluegill in the lakes in order to estimate growth rates of the species in northern Indiana. The Chapman Lake Conservation Club (CLCC) installed a water control structure in 1947. The Indiana Department of Natural Resources (IDNR) began assessing the condition of Big and Little Chapman Lakes in 1964 in response to problems with fisheries and aquatic vegetation reported by CLCC and the Chapman Lake Fish and Game Club (CLFGC). The IDNR also surveyed Big Chapman Lake in 1976, 1980, 1981, 1989, and 1999 and Little Chapman Lake in 1969, 1976, and 1999. Lists of species observed in the Chapman Lakes are presented in Appendix 8.

Stocking Efforts

Six different species of fish have been stocked in the Chapman Lakes since the 1950s when CLFGC first stocked smallmouth bass, largemouth bass, redear, and bluegill. From 1958 to 1963, 2600 rainbow trout were stocked in Big Chapman Lake. Largemouth bass were restocked in Little Chapman Lake following a 1967 partial panfish eradication. CLFGC began stocking walleye in 1961. Pearson (1980) noted that from 1962-1979, CLFGC stocked 6,250 fry, 6,580 fingerlings, and 125 sub-adult walleye. The IDNR continued stocking fry and juvenile walleye from 1980 to 1987 as part of the intensive effort to increase walleye fishing opportunities in the state.

Big Chapman Lake

1964 Survey

The first IDNR survey (McGinty, 1964) classified the lake as a largemouth bass, bluegill, and redear fishery. Yellow perch and crappie were also important components of the fishery. Largemouth bass were not abundant and in poor condition, while bluegill had only fair growth rate but were reaching catchable size. The survey noted that catch rates for both bass and bluegill had been declining in recent years. However, redear were plentiful with good growth rates. Twelve walleye were collected. The survey report recommends aquatic vegetation control (particularly of *Chara* sp.) in the excavated channels around the lake. Fisheries management recommendations include: 1) introduction of another game species like white bass; 2) discontinuation of walleye stocking due to their apparent inability to survive; 3) consideration of stocking channel catfish instead of walleye; 4) installation of fish habitat structures. The report cautions that due to the lake's low fertility, it may not have the ability to support a large fish biomass.

1976 Survey

In 1976, the IDNR survey (Shipman, 1976) documented a stable fishery that had not changed much since the 1964 study. Bluegill dominated the sampling effort by number (38.3%) followed by gizzard shad (14.7%), longear (9.1%), yellow perch (8.1%), redear (7.1%), and largemouth bass (5.6%). Small bluegill and redear were of above average condition; however, large individuals of the species were of below average conditions, and growth rates were at or below average. The report attributes poor growth to the relatively unproductive lake rather than to overabundance and stunting. Shad densities were not considered problematic. Longear condition and growth rate were average, while yellow perch condition and growth rate were below average. Although all largemouth bass were 15 inches (38.1 cm) or smaller, the report summarizes the present population as "stable". Two walleye were collected during the study, and because the IDNR was not aware of stocking within the past five years, these walleye were believed to have been from natural reproduction. Therefore, the report recommends placement of Big Chapman Lake on the IDNR walleye stocking list.

1980 Preliminary Walleye Investigation

In 1980, the IDNR (Pearson, 1980) conducted a preliminary investigation of the walleye populations of the Chapman Lakes due to the suggestion of natural reproduction (Shipman, 1976). Four walleye were netted in the 1980 study. Even though Big Chapman Lake yielded higher catch rates than other natural lakes in the area, the population was not large in comparison to other reservoirs and midwestern lakes. The 1980 study reported fingerling stocking in 1972 and 1973 indicating that walleye netted in the 1976 study were not the result of natural reproduction. The low catch rates in 1976 and 1980 indicated that stocked walleye were not reproducing significantly enough to maintain the fishery and that stocked walleye mortality had been high. Due to the small amount of inconclusive data on natural walleye reproduction in the lakes, the IDNR recommended: 1) discontinuing stocking of other predaceous fish in order to reduce small walleye mortality; 2) stocking of 110,000 walleye fingerlings in 1982 and 1984.

1981 Creel Survey

In order to determine fishing pressure, fishing harvest, and angler interest at Big Chapman Lake, the IDNR conducted a creel survey in the spring and summer of 1981 (Pearson, 1981). The survey consisted of angler interviews for catch data and sampling of walleye scales for age analysis. According to the survey, Big Chapman Lake experienced only light fishing pressure relative to other lakes in the area. Most anglers fished for bass, bluegill, and crappie, and those three species dominated the harvest by number. Walleye fishing interest and harvest were low. The creel survey determined that walleye were not successfully reproducing in the lake. No walleye had been stocked in 1978, and the survey failed to document any age-three walleye; therefore, walleye were not naturally reproducing in Big Chapman Lake. Additionally, no age-one walleye were represented in the catch, indicating that the 1980 stocking was unsuccessful or that the age-one fish were still too small to be caught. The report recommends that the IDNR undertake an intensive walleye stocking and sampling program in order to increase the population and angler interest.

1989 Largemouth Bass Study

The IDNR conducted a study from 1983-1988 (Shipman, 1989) to evaluate changes in largemouth bass population size and mortality after a 14-inch size limit was imposed in 1984 and to evaluate angler opinions and attitudes toward the size limit. Anglers fished mostly for bluegill and bass, while bluegill (76%), perch (7%), and crappies (7%) dominated the harvest. After the 14-inch size limit was instituted, the density of intermediate (sub-legal) size bass increased, while their growth rate declined. The decline in growth rate was accompanied by an increase in harvested panfish size indicating a scarcity of prey for the intermediate-size bass. Catch-and-release fishing for sub-legal-size bass tripled, and initially, fisherman generally supported the 14-inch limit. However, support weakened when numbers of large, harvestable bass did not increase. The report suggests that once the initially-protected, slow-growing year classes (1981, 1982, 1983) were removed, growth rates and harvest of legal-size bass would increase and sub-legal bass density would decline. The 1983-1988 survey generated three recommendations involving Big Chapman Lake: 1) consider special regulations if future surveys show no improvement in growth rate or population structure; 2) examine changes in forage fish density related to increased bass density during future surveys; 3) conduct additional studies to determine what role catch-and-release mortality plays in natural mortality.

1991 Survey

As recommended in 1989, Big Chapman Lake was monitored again in 1991 (Pearson, 1991) for 14-inch size limit assessment. The survey documented 28 species with bluegill as the most dominant species (38%), followed by yellow perch (15%) and largemouth bass (15%). Bullhead and gar were commonly captured while carp, crappie, walleye, pike, and white bass were rare. Bluegill growth rate had improved with individuals reaching nine inches in length. Twenty-two percent of perch were greater than ten inches (25.4 cm), and growth rates were normal. The survey found no largemouth bass greater than 14 inches (35.6) in length with the poor growth evidence of excessive bass density. Compared to the 1964 and 1976 surveys, shad populations were greatly reduced and comprised of only 16 to 18-inch (40.6 to 47.7 cm) individuals. Shad recruitment was evidently greatly reduced. The 1991 report again calls attention to the relatively unproductive nature of the lake and points out that this lack of productivity may in part be responsible for the failures of past management strategies. Competition for limited food resources in the lake could limit game-fish production in Big Chapman Lake. The IDNR discouraged any future fish stocking due to resource competition issues and suggested the possibility of future fishing regulations that may be better suited for application to unproductive, natural lakes.

1999 Survey

In May 1999, the IDNR conducted a sampling targeted only at bass in order to get a more precise estimate of bass numbers and sizes. According to Jed Pearson, an IDNR fisheries biologist, these spring estimates are more precise than routine summer estimates for several reasons: 1) Larger bass move into shallower waters in May for spawning making them more vulnerable to electroshocking equipment. 2) Spring samples are targeted only at bass, while during routine summer surveys, netters sample all species and may miss more bass. 3) Warmer water and denser aquatic vegetation during summer months also play a role in reducing routine bass catch rates. The May 1999 bass sampling noted 103 bass of legal size, a bass catch rate similar to other lakes in northern Indiana, and double the percentage of 14 to 17.5- inch bass seen in other area lakes. As expected, bass caught later during the routine June sampling were fewer in number and smaller in size. During June, only five of the 56 largemouth bass captured were of legal size, and intermediate-size bass were almost one inch shorter than similar age bass of other lakes. However, the survey documented increased numbers of 12 to 14-inch bass, a ten-fold increase in catch rate of 14 to 17.5-inch individuals, and stabilization of growth rate. Aside from largemouth bass, the survey documented 28 other species. The species most prevalent in 1991 (bluegill, yellow perch, and largemouth bass) dominated the 1999 catch as well. Bluegill growth rate had slowed, and the majority of individuals were three to four inches in size. Perch growth rate was also slow. The report concludes that fishing at Big Chapman Lake was satisfactory and that fishing pressure had not negatively affected bluegill or bass. In fact, largemouth bass abundance and size increased perhaps due to the imposed size limit. Finally, the survey report recommends protection of undeveloped shorelines and their adjacent wetlands and reduction of pollution (sediments and nutrients) from Crooked Creek. The IDNR report advocates working with concerned local constituencies to preserve the natural character of the lake.

Little Chapman Lake

1969 Fish Eradication Survey

The 1969 survey of Little Chapman Lake (Hudson, 1969) documented the results of a 1967 partial fish eradication using rotenone. The purpose of eradication was to reduce numbers of stunted panfish. The survey found twenty species of fish in Little Chapman Lake. Bluegill and bass dominated the catch by number (60%), and the bass and bluegill fishery was rated as satisfactory. Even though growth rates of the two species were only average, fish condition was improved based on 1964 estimates. Other dominant fish species captured in the survey in order of decreasing abundance were: lake chubsucker, redear, yellow perch, longear, warmouth, pumpkinseed, and gizzard shad. A complete list of fish species found in Little Chapman Lake may be found in Appendix 8. The IDNR recommended the continuation of aquatic plant control (especially milfoil control) in order to reduce cover and protection for small bluegill.

1976 Survey

Bluegill and gizzard shad dominated the 1976 survey by number (Shipman, 1976) followed by yellow perch, largemouth bass, and lake chubsucker. Bluegill were of average condition while growth rate was below average. The survey noted little change in the bluegill population since the 1967 eradication. Only 57 adult shad were collected indicating that the lake did not appear to have an overabundance problem. Yellow perch were a large constituent of the fishery before the eradication and seemed to be returning to previous density levels. Young-of-the-year largemouth bass dominated the overall catch of bass in the 1976 survey, an indication of a growing bass population with good recruitment. Largemouth bass were growing normally and were of above average condition. Chubsucker were more abundant than they had been before the 1967 kill. The report classified Little Chapman Lake as fairly productive with a good panfish fishery and a stable bass population. The IDNR study recommended stocking walleye due to the large numbers of forage fish like gizzard shad, lake chubsucker, and yellow perch present in the lake.

1999 Survey

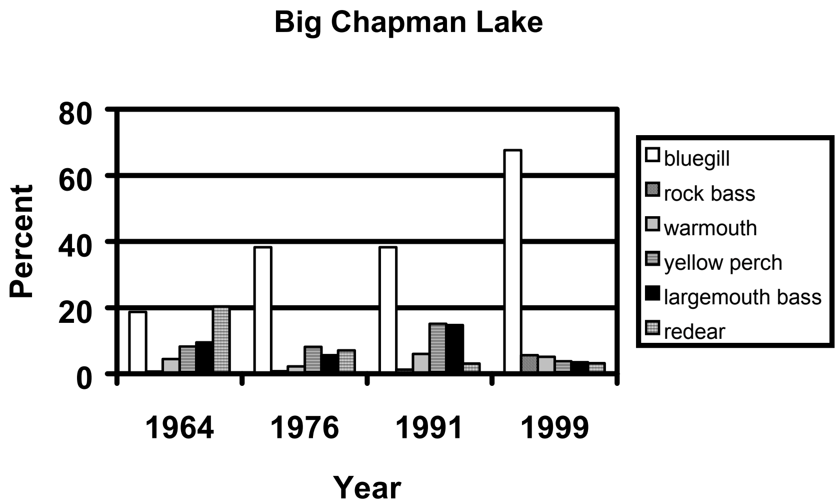
The 1999 DNR survey of Little Chapman Lake was designed to obtain current information on the fish community and fishery of the lake. Twenty-five species were collected with bluegill dominating the catch by both weight (32%) and number (80%). Gizzard shad, northern pike, and largemouth bass were the next three most dominant species. Bluegill and bass were of average growth rate, and catch rates of the species were high compared to rates at other area lakes. The yellow perch collected were small in size and of below average growth rates. The largest pike caught during the survey weighed eight and one-third pounds. Northern pike were caught more frequently at Little Chapman Lake than at other lakes in the area. The fish community composition had changed very little with bluegill, yellow perch, largemouth bass, and gizzard shad as the dominant species. However, northern pike had not been documented prior to the 1999 survey. The study concluded that bluegill, perch, bass, and pike fishing were satisfactory with redear, warmouth, and other sport fish adding fishing diversity. Resounding the 1976 recommendation, the report points out the possibility that the lake may be able to support more predator fish like walleye due to large numbers of forage fish. The IDNR also noted protection of the natural habitat and water quality as a priority.

Summary

Figure 46 summarizes the relative abundance of dominant fish species found in the Chapman Lakes from the 1960s to 1999. The Chapman Lakes' fishery is typical of many lakes in northeastern Indiana. In Big Chapman Lake, bluegill dominate the fishery with rock bass, warmouth, yellow perch, largemouth bass, and redear accounting for much of the remaining fish community. The fishery of the more productive Little Chapman Lake is similar, though gizzard shad are present in greater numbers. The bluegill, yellow perch, and largemouth bass fisheries are classified as satisfactory with other dominant species adding fishing diversity. Although largemouth bass populations fluctuate fairly often, the Big Chapman Lake population appears to be benefiting from the 14-inch size limit. The most recent survey documented increased catch rates and growth rate stabilization. In addition to bluegill and bass fishing opportunities, Little Chapman supports a higher catch rate of northern pike when compared to other area lakes. Gizzard shad and other forage fish do not pose problems for the fisheries, though the forage base of Little Chapman Lake may support additional game fish species.

While the IDNR fisheries reports indicate that fishing quality of the two lakes has changed relatively little over the past few decades. This contrasts with the views of many lake residents. When asked whether fishing had improved or declined over the years, resident survey respondents provided mixed answers. Thirteen percent felt fishing had improved, while 38% believed fishing quality of the lakes had declined. More details regarding the lake residents' views on the lakes' fisheries is provided in the Resident Survey Section.

Regardless of individual views on the fisheries, fishing is a very popular activity on the lake with over 70% of the respondents to the resident survey noting that they fish on the lakes. Thus, residents should continue to support good fisheries management efforts on the lakes. This includes implementing recommendations of IDNR fisheries biologists. Residents may also assist IDNR fisheries biologists in determining any future stocking efforts on the lake. The IDNR invested considerable time and money in the walleye stocking program, yet creel surveys indicated low angler interest in walleyes. Organized, collective input from lake residents regarding fishing preferences could assist IDNR biologists in directing limited resources to the lakes. Lastly, lake residents should encourage conservation practices that preserve native shoreline and wetland habitat to protect fish spawning grounds. Lake residents may also want to consider planting native emergents in front of their seawalls to restore littoral zone habitat critical for fish survival. Suggested species for such plantings are listed in the following section on rooted aquatic plants. This, along with restoration efforts in the watershed, will help protect the diverse fisheries that exist in the Chapman Lakes.



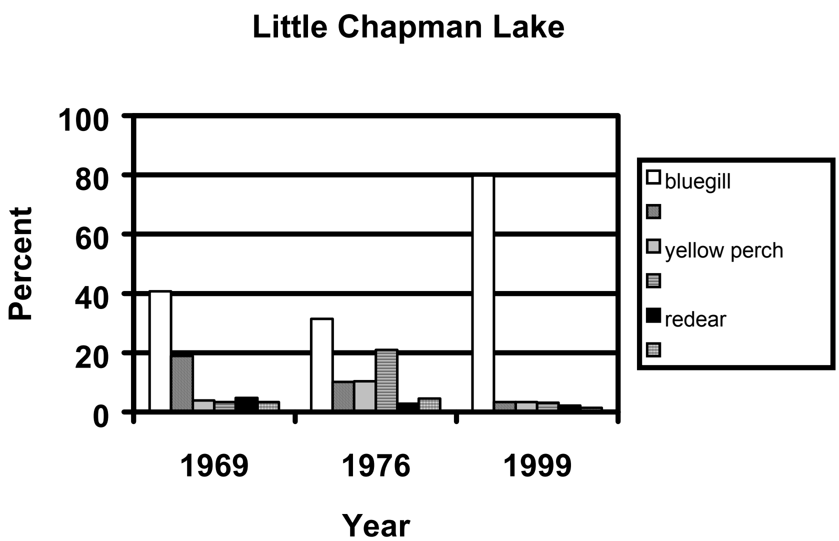


FIGURE 46. Relative Abundance of Dominant Fish Species in the Chapman Lakes, 1964-1999. Data source: IDNR fisheries surveys.

UNIONIDS

Unionid Species in the Chapman Lakes

The Upper Tippecanoe watershed, which encompasses the Chapman Lakes is historically known for its diverse community of unionids (mussels) including several federally endangered species. The Indiana Department of Natural Resources is currently working on a natural lakes mussel survey documenting the presence of mussels in each natural lake. In 1999, both Big and Little Chapman Lake were surveyed for the presence of mussels (Brant Fisher, personal communication). Little Chapman hosted three native unionid species including fatmucket (*Lampsilis siliquoidea*), pondmussel (*Ligumia subrostrata*), and giant floater (*Pyganodon grandis*). The same three species plus the spike mussel (*Eliptio dilata*) were found in Big Chapman Lake. Two exotics, the Asiatic clam (*Corbicula imbecillis*) and zebra mussels (*Dreissena polymorpha*), were also found in both lakes.

Zebra Mussels

Zebra mussels are an exotic species of concern for many lakes and rivers throughout the state and for the Chapman Lakes as well. Zebra mussels are small, fingernail-size, freshwater mollusks which are native to the Caspian, Black, and Aral Seas of Eastern Europe. Mature females can produce between 30,000 and 100,000 eggs per year which hatch into larvae, called veligers, the size of the period at the end of this sentence. Within two to three weeks of hatching the veliger shells begin to harden and become able to attach and detach from hard surfaces like rock, wood, glass, rubber, metal, gravel, other zebra mussels and shellfish. Zebra mussel shells were found attached to native mussel shells during the aquatic plant survey of the Chapman Lakes during the summer of 2000.

Zebra mussels are one of at least 139 non-indigenous aquatic species that have become established in the Great Lakes area since the early 1800s. They were probably introduced from transoceanic ship ballast water around 1986. They rapidly spread throughout the Great Lakes and into several river systems of the eastern U.S. including the Ohio, Illinois, Mississippi, Mohawk, Hudson, Susquehanna, Tennessee, and Arkansas. Zebra mussels were probably first introduced into the Chapman Lakes in the mid-1990s. Larry Clement (personal communication) of The Nature Conservancy claims that because larger Indiana lakes received zebra mussels first, the primary cause of their spread has been via boat transport from Lake Michigan. Experts accredit their rapid spread mainly to veliger drift in currents and transport from one water body to another via bilges, bait buckets, and ballast water. Zebra mussels will likely continue spreading throughout most of the U.S. unless effective preventative measures are employed.

Property damage and ecosystem impairment can be attributed to the nuisance exotic species. Zebra mussels pose a multi-billion dollar threat to water supplies for municipalities, industry, and agriculture and cause costly damage to shoreline facilities and residences. Mussel colonies, reaching densities of 115,000 / m^2, can clog water intake pipes, valves, and screens at municipal water facilities, industrial facilities, and power plants. The mollusks cause costly shipping and boating damages by atttaching to motors, propellers, buoys, hulls, and cooling systems of engines. Zebra mussels also have detrimental effects on the biological and ecological functions of aquatic ecosystems in North America. They colonize the shell surfaces of native unionid mussels disrupting feeding, locomotion, respiration, and reproduction. Death usually occurs within two years. Due to the zebra mussel invasion and other environmental problems, fifty-five percent of native North American unionid mussels are extinct or imperiled. The presence of zebra mussel colonies on weathered shells of native unionids in the Chapman Lakes suggest that zebra mussels are adversely affecting the lakes' native mussel.

Zebra mussels are efficient filter-feeders and consume large amounts of phytoplankton (microscopic algae) which are food for zooplankton (small animals) that nourish small fish. Without the plants at the base of the food chain, zooplankton populations decline causing fish recruitment to decline as well. Additionally, mussels essentially filter out contaminants like PCB and other hazardous hydrocarbons from the water column and concentrate them in their tissues. The toxins may then be biomagnified in mussel predators higher in the food web. Filter-feeding also results in a rerouting of dissolved and particulate-bound contaminants from the water column to the sediments in the form of feces and pseudofeces where benthic or bottom-feeding invertebrates may ingest them. Fish consuming the invertebrates further biomagnify the toxins, and since zebra mussel introduction, PCB concentrations in top-predators have increased.

Because zebra mussels did not evolve in North America, infected waters lack an efficient predator to biologically control their populations. Although diving ducks, freshwater drum, carp, sturgeon, sunfishes, and suckers do eat mollusks, no predator is capable of controlling mussel populations. Introducing other Eurasian molluscivores is risky because biomanipulation efforts often fail since introduced predators will not feed on the introduced pest or will not inhabit the areas occupied by the pests. Historically, the introduced predator has become an invader itself or has negatively affected other native species.

Zebra mussels also affect water quality by altering the sediments and the water column of infested water bodies. Colonies of mussels increase the amount of benthic organic matter through the production of waste products. A shift in the community composition of the invertebrates that inhabit the benthic sediments occurs, and invertebrates usually indicative of poorer water quality become dominant (like tubificid oligochaetes and chironomids). Zebra mussels are also associated with an increase in water clarity and light penetration which in turn may result in increased macrophytic vegetation growth. However, they selectively filter out small forms of phytoplankton (diatoms and cryptophytes), with no impact on colonial and filamentous cyanobacteria. Nutrient resources no longer used by the small members of the algal community become available to cyanobacteria causing noxious blooms. Zebra mussels even release large amounts of bioavailable nitrogen (ammonium, NH_4^+) which may be utilized by large, undesirable algae. Additionally, the invading mussels are associated with increasing fractions of dissolved, bioavailable toxins in the water column.

Because recreational boating is the primary way for dissemination of adult and larval zebra mussels, following some simple precautions can help prevent the spread of this aquatic nuisance organism:

1. Remove visible vegetation from equipment and objects that were in the water.
2. Flush engine cooling system, live wells, and bilge with hot water or tap water. Water of 110°C and 140°C will kill veligers and adults respectively.
3. Rinse any other areas that get wet like trailers, boat decks, etc.
4. Air dry boat and equipment for two to five days before using in uninfested waters.

5. Examine boat exterior if it has been docked in mussel-infested waters. If mussels or large amounts of algae are found, clean the surfaces or dry the boat for at least five days.
6. Do not reuse bait or bait bucket water if they have been exposed to mussel-invaded waters.

Many times recreationists are the first to document exotic species in an area. To help local natural resource officials, learn how to identify exotic species associated with the Kosciusko County Natural Lakes Area. If an unidentifiable fish or other aquatic organism is encountered, note the date and location where the specimen was found and collect it if possible. Store it in rubbing alcohol and contact the local USFWS or state natural resources office. Many times recreationists are the first to document exotic species in an area. Identify zebra mussels by:

1. Shell Appearance: zebra mussels look like small D-shaped clams of a yellow or brown color. The shell is characterized by light and dark striping resembling tiger stripes.
2. Size and Location: most zebra mussels are only the size of a fingernail but may be up to two inches long. They tend to grow in colonies of multiple individuals in shallow, productive waters.
3. Attachment: no other freshwater mussels can firmly attach themselves to solid substrates.

AQUATIC MACROPHYTE SURVEY

A general macrophyte (rooted plant) survey of the Chapman Lakes was conducted on August 29, 2000. The survey located areas with high densities of submerged and emergent aquatic vegetation in the lake. Due to the limited scope of this LARE study, the survey consisted of a general reconnaissance in shallow areas of the lakes. In areas possessing the greatest density of rooted plant growth (based on visual observation), random rake grabs were performed to determine the species present. No quantitative measures of species abundance or percent cover were recorded. While this methodology has some shortcomings, it provides good information on the dominant species present and extent of coverage in the lake from which general management recommendations can be made.

Beds mapped on Figure 47 reflect areas with high density and high diversity (relative to the Chapman Lakes). A complete list of plants found in the Chapman Lakes during this survey as well as historical surveys are presented in Appendix 9. Before detailing the results of the macrophyte survey, it may be useful to understand the conditions under which lakes may support macrophyte growth. Additionally, an understanding of the roles that macrophytes play in a healthy, functioning lake ecosystem is necessary.

Conditions for Growth

Like terrestrial vegetation, aquatic vegetation has several habitat requirements that need to be satisfied in order for the plants to grow or thrive. Aquatic plants depend on sunlight as an energy source. The amount of sunlight available to plants decreases with depth of water as algae, sediment, and other suspended particles block light penetration. Consequently, most aquatic plants are limited to maximum water depths of 5 or 6 feet (1.5 to 1.8 m), but some species, such as Eurasian water milfoil, have a greater tolerance for lower light levels and can grow in up to 12 feet (3 m) of water. Based on this, aquatic plant growth may be light-limited to 215 and 50 acres

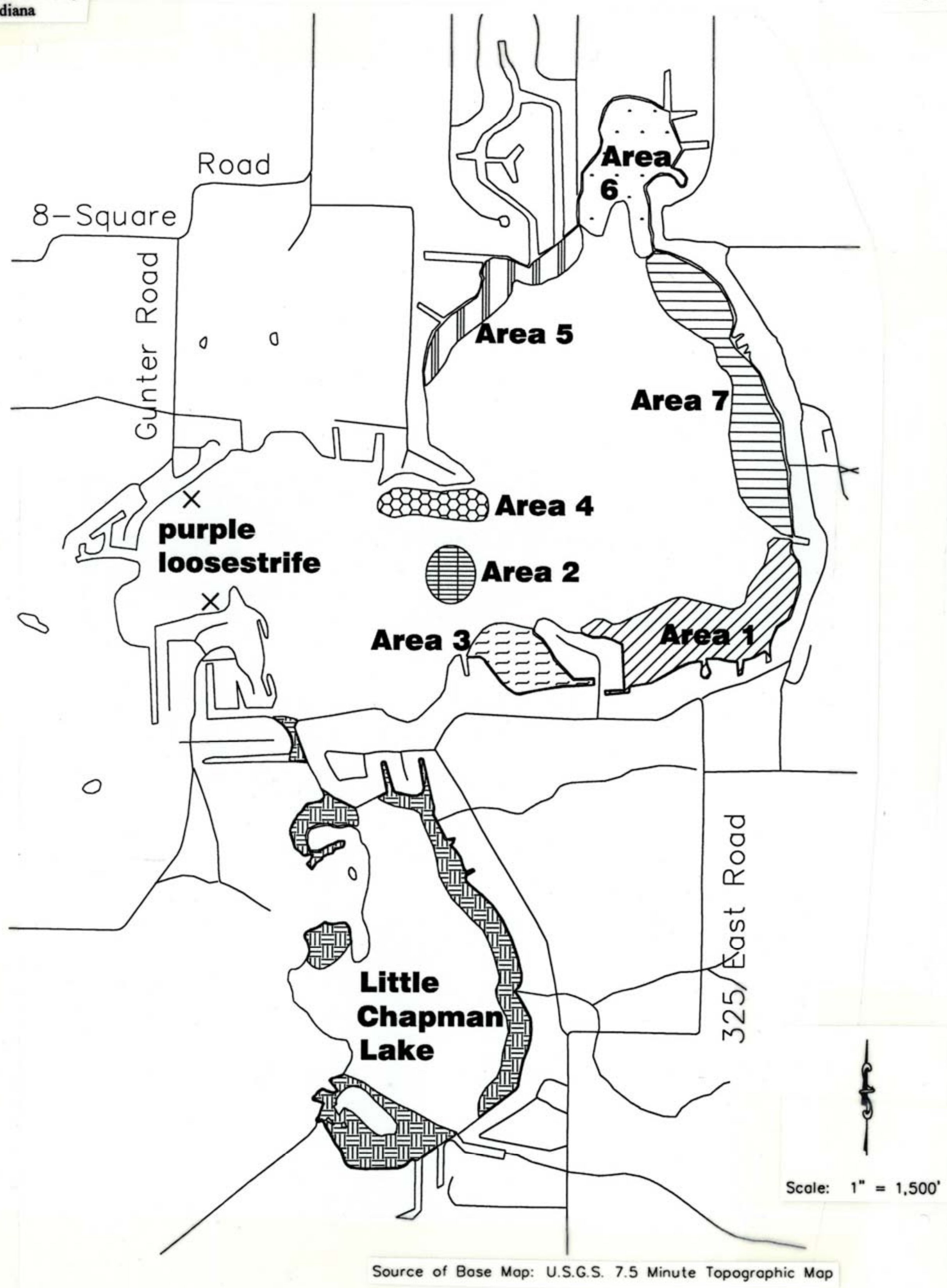


FIGURE 47. High Density and High Diversity Areas of Aquatic Vegetation in the Chapman Lakes

(87 and 20 ha) of the lakes, respectively, according to the depth-area curves for Big and Little Chapman Lakes (Figures 33 and 35).

Lakes with greater water clarity have a greater potential for plant growth. Big Chapman Lake's Secchi disk transparency of 7.5 feet (2.3 m) is deeper than most Indiana lakes suggesting a greater potential for rooted plant growth. This is further supported by the lake's 1% light level, which is a fairly deep 23.5 feet (7.2 m). This suggests that low levels of light reach deep areas of the lake. Based on this data, light is not likely a factor limiting rooted plant growth in Big Chapman Lake. (See the In-Lake Sampling Section for more details on water quality characteristics.)

Aquatic plants also require a steady source of nutrients for survival. Aquatic macrophytes differ from microscopic algae (which are also plants) in their uptake of nutrients. Aquatic macrophytes receive most of their nutrients from the sediments via their root systems rather than directly utilizing nutrients in the surrounding water column. Some competition with algae for nutrients in the water column does occur. The amount of nutrients taken from the water column varies for each macrophyte species. Because macrophytes obtain most of their nutrients from the sediments, lakes which receive high watershed inputs of nutrients to the water column will not necessarily have aquatic macrophyte problems.

The type of substrate present affects a lake's ability to support aquatic vegetation. Lakes that have mucky, organic, nutrient-rich substrates have an increased potential for plant growth compared to lakes with gravelly, rocky substrates. Substrate may be the factor most limiting rooted plant growth in the lakes. The substrate of Big Chapman Lake, in particular, consists largely of sand and marl providing little nutritional base for rooted plants. As described further in the results portion of this section, plant density was greatest in the manmade channels that were dug through organic muck wetlands surrounding the lakes. This soil has an ample supply of nutrients to support macrophyte growth. Increased density was also noted in areas that receive sediment input from the watershed. These sediment inputs from a largely agricultural watershed provide a substrate that is high in nutrients and is, therefore, able to support dense aquatic macrophyte growth.

The forces acting on a lake's substrate also affect aquatic vegetation growth. Lakes that have significant wave action that disturb the bottom sediments have decreased ability to support plants. Disturbance of bottom sediment may decrease water clarity, limiting light penetration or may affect the availability of nutrients for the macrophytes. Wave action may also create significant shearing forces prohibiting plant growth altogether.

Boating activity may affect macrophyte growth in conflicting ways. Rooted plant growth may be limited if bottom sediments are regularly disturbed by boating activity. This is possible on the Chapman Lakes where, according to the resident survey, most (83%) residents own at least one type of boat. Complaints about boating speed and personal watercraft further supports the hypothesis that some macrophyte growth may be limited by boating activity. Alternatively, boating activity in rooted plant stands of species that can reproduce vegetatively, such as Eurasian water milfoil, may increase macrophyte density rather than decrease it.

Ecosystem Roles

Aquatic plants are a beneficial and necessary part of healthy lakes. Plants stabilize shorelines holding bank soil with their roots. The vegetation also serves to dissipate wave energy further protecting shorelines from erosion. Plants play a role in a lake's nutrient cycle by uptaking nutrients from the sediments. Like their terrestrial counterparts, aquatic macrophytes produce oxygen which is utilized by the lake's fauna. Plants also produce flowers and unique leaf patterns that are aesthetically attractive.

Emergent and submerged plants provide important habitat for fish, insects, reptiles, amphibians, waterfowl, shorebirds, and small mammals. Fish utilize aquatic vegetation for cover from predators and for spawning and rearing grounds. Different species depend upon different percent coverages of these plants for successful spawning, rearing, and protection for predators. For example, bluegill require an area to be approximately 15-30% covered with aquatic plants for successful survival, while northern pike achieve success in areas where rooted plants cover 80% or more of the area (Borman et al., 1997).

Aquatic vegetation also serves as substrate for aquatic insects, the primary diet of insectivorous fish. Waterfowl and shorebirds depend on aquatic vegetation for nesting and brooding areas. Numerous aquatic waterfowl were observed utilizing the lakes as habitat during the macrophyte survey. Aquatic plants such as pondweed, coontail, duckweed, water milfoil, and arrowhead, also provide a food source to waterfowl. Duckweed in particular has been noted for its high protein content and consequently has served as feed for livestock. Turtles and snakes utilize emergent vegetation as basking sites. Amphibians rely on the emergent vegetation zones as primary habitat.

Historical Macrophyte Reports

Big Chapman Lake

The aerial photographs in Appendix 5 provide insight into the historical rooted plant coverage in Big Chapman Lake. The pattern in vegetative cover appears to have changed little from 1938. This pattern also roughly corresponds to the shallow areas on the lake's bathymetric map (see Figure 32).

The Indiana Department of Natural Resources (IDNR) Fisheries Surveys record brief descriptions of the rooted plants in the lake. A 1964 survey (McGinty, 1964) reports "extensive areas without aquatic vegetation" in Big Chapman. It notes that the manmade channels support the densest macrophyte growth. Dominant submerged species included coontail, bushy pondweed, elodea, milfoil, and chara. The report lists soft rush as the dominant emergent, although it is likely that this is a misidentification of bulrush.

A decade later, an IDNR Fisheries Survey (Shipman, 1976) highlighted the relatively low productivity of the lake. Bulrush, cattails, and milfoil dominated the lake according to this survey. The report reiterates that vegetation is of concern in the channels. Surveys conducted in the 1990's (Pearson, 1991 and 1999) found similar dominant species as those listed in the 1976 survey. The reports note an increased abundance of curly leaf pondweed, but again large areas of unvegetated shallows existed at the time of survey. Purple loosestrife was first noted in the 1991 survey. Submerged plant density in the channels remained a concern. (Appendix 9 provides a complete list of macrophyte species found in historical surveys on Big Chapman.) None of the fisheries surveys recommend any large-scale control measures.

Little Chapman Lake

Like Big Chapman Lake, the historical record of macrophytes in Little Chapman Lake is sparse. A 1969 IDNR Fisheries Report (Hudson, 1969) notes the abundance of milfoil, coontail, and chara along the west end of the lake. (Given the present characteristics of the lake, it is likely that this is a typographical error in which west was substituted for east.) The document reports milfoil growing to a depth of approximately 8 feet (2.4 m) and recommends "aquatic weed control be continued in an effort to reduce the excess cover and unnecessary protection afforded to panfish." A follow up fisheries survey conducted in 1976 (Shipman, 1976) reiterates the abundance of milfoil especially in the channels off the lake. A 1999 IDNR Fisheries Report (Pearson, 1999) describes coontail, curly leaf pondweed, and milfoil as common in the lake. The presence of these species was noted in water up to 14 feet (5.8 m) deep. Chara was also noted as abundant at the time of the survey. Appendix 9 provides a complete list of species found in historical surveys on Little Chapman.

Current Survey Results

Big Chapman Lake

Area 1

Area 1 is located near the boat ramp in the southeast corner of the lake (Figure 47). Vegetation in Area 1 consists of emergent stands as well as submerged growth. An emergent island parallels the southern shoreline in this area. Dominant species in the emergent island include narrow-leaved cattail, rose mallow, button bush, whorled loosestrife, jewelweed, and hard stem bulrush. This island is likely the remnant of a larger wetland complex that formed the lake's shoreline prior to residential development. Today, however, a channel is cut between the emergent island and the southern shoreline. Submerged species including milfoil, eel grass, and slender naiad dominate in this channel.

Several large patches of large stem bulrush are scattered in deeper water directly north of the emergent island described above. White water lilies float in these stands of bulrush. Spiny naiad, eel grass, and chara dominated the submerged community surrounding the bulrush stands. Eurasian water milfoil, Sago pondweed, Illinois pondweed, curly leaf pondweed, and grass-leaved pondweed were also noted in the submerged community. Small duckweed was observed on the water's surface in Area 1.

In the eastern portion of Area 1, Eurasian water milfoil is the dominant submerged species. Grass-leaved pondweed, long-leaved pondweed, eel grass, and coontail were noted in lesser quantities. The portions of Eurasian water milfoil plants floating on the surface were blackish brown in color and appeared dead. A contact herbicide may have been applied to these plants prior to the survey.

Area 2

Area 2 is a shallow water area in the central portion of Big Chapman Lake. The bathymetric map (Figure 32) records 6 feet as the maximum depth in this area suggesting the potential for rooted plant growth. Aerial photography confirms that plant growth occurs in Area 2. At the time of the survey, rooted plant growth was limited to approximately 300 square feet; vegetation growth did not extend throughout the entire 6-foot water depth. Area 2 was vegetated with a diverse (relative to other rooted plant beds in Big Chapman Lake) mix of species including Illinois pondweed, Sago pondweed, grass-leaved pondweed, spiny naiad, eel grass, bladderwort, and chara.

Area 3
Area 3 is a protected cove located along the southern shoreline directly south of Area 2. Emergent stands of hard stem bulrush vegetated shallow water depths closest to the shoreline. Long-leaved pondweed, grass-leaved pondweed, and chara dominated the submerged community in Area 3. The submerged vegetation did not completely cover the cove, but rather formed isolated beds scattered throughout the cove.

Area 4
Area 4 is located along the northern shoreline northwest of Area 2. As in Areas 1 and 3, thin stands of hardstem bulrush vegetated shallow depths of Area 4 adjacent to the lake's shoreline. Spiny naiad and chara were observed at deeper depths. In general, however, the vegetation was sparse in comparison to other areas described above.

Area 5
Area 5 represents the lake's northwest shoreline. Eurasian water milfoil, coontail, and eel grass beds were noted scattered along this shoreline. Slender naiad, chara, and elodea were observed in lesser quantities. Patches of Illinois pondweed existed in deeper water further from the shoreline. Coontail and eel grass beds were observed further off-shore as well. The macrophyte community of Area 5 resembled that found along the eastern shoreline of Little Chapman Lake.

Area 6
Area 6 is located in a protected cove in the northeast corner of the lake. In comparison to other areas of the lake, Area 6 contained the densest coverage of submerged vegetation. Eurasian water milfoil dominated in Area 6, but beds of spiny naiad, Sago pondweed, and coontail were also present. Emergent wetland bordered the western edge of this cove. Dense strips of Eurasian water milfoil were observed along the buoy line marking the low-speed zone. Narrow-leaved cattails dominate the emergent wetland. Rose mallow, dogwood shrubs, and pickerel weed were also observed in the wetland. Patches of spatterdock and white water lilies extended out from the wetland edge. Duckweed was noted floating in much of the cove.

Area 7
Area 7 is located south of Area 6 and adjacent to the lake's eastern shoreline. A stand of cattails occupied the shallow water near the shoreline. Moving south from Area 6, the submerged community shifted from a dominance of Eurasian water milfoil to mixed beds of Illinois pondweed and Sago pondweed. Chara mats were noted in portions of Area 7, particularly close to the cattail stand.

Little Chapman Lake
Eurasian water milfoil, coontail, and eel grass dominated the water immediately adjacent to the eastern shoreline of Little Chapman Lake. This submerged vegetation extended approximately

25-50 feet (8-15 m) from the shoreline in most places, but extended up to 150 feet from shore. Vegetation was densest in the protected areas in the northeast corner of the lake. The vegetation thined further south along the shoreline.

An emergent wetland borders the western side of Little Chapman Lake. Narrow-leaved cattail dominated the emergent community. Rose mallow, whorled loosestrife, jewelweed, false nettle and willows were also noted. In contrast to the shallow water adjacent to the eastern shoreline of Little Chapman, the shallow water along the western shoreline was sparsely vegetated. Dominant submerged species included eel grass and chara. Patches of spatterdock and white water lilies were established in the three protected coves on the western side of the lake. Eurasian water milfoil was observed in the southern cove in addition to the floating species.

The channel connecting Big Chapman to Little Chapman contained a variety of submerged species. Eel grass dominated the center of the channel. Northern milfoil, Eurasian water milfoil, Sago pondweed, slender naiad, long-leaved pondweed, white water star, and chara were observed adjacent to the emergent vegetation on the west side of the channel.

Discussion and Summary

Big and Little Chapman Lakes support two very different rooted plant communities. A diverse mix of native pondweeds, eel grass, and emergent vegetation grows in patches throughout Big Chapman Lake. The lake is also characterized by large expanses of shallow water in which rooted plant growth is absent. Because in-lake sampling suggests sufficient light is present for the establishment of rooted plant growth throughout much of Big Chapman Lake, growth is likely limited by the marl and sand substrate in many portions of the lake. This substrate may not provide enough nutrients to support dense vegetative growth. The heaviest plant growth was noted in the channels and Nellie's Bay. The muck substrate in these areas provides a rich nutrient source for plants. Nuisance levels of Eurasian water milfoil are limited to the channels and the eastern shoreline. The lake's largest inlet, Crooked Creek, and several smaller drainages carry nutrient-rich sediment from the watershed's agricultural land to the eastern portion of the lake. Dense Eurasian water milfoil beds are established on the sediment deltas.

In contrast, Little Chapman Lake offers a lower diversity of species with Eurasian water milfoil, eel grass, and coontail dominating the rooted plant mix. As similarly observed on Big Chapman Lake, heaviest growth of these plants was noted in the channels and a protected cove. These areas have muck substrates that are capable of supporting extensive rooted plant populations. Heavy plant growth also extended south from the protected cove. This area receives sediment from Arrowhead Drain. Like the load from Crooked Creek, this sediment is likely nutrient-rich, providing excellent substrate for rooted plants. The western portion of the lake supports an emergent marsh dominated by cattails. Submerged aquatic vegetation in deeper water adjacent to the marsh is limited. The marl and sand substrate in that area (beyond the muck of the marsh) likely restricts prolific rooted plant growth.

Little Chapman Lake shares with many other lakes in the region similar characteristics. These characteristics include: relatively low diversity and heavy plant growth, in particular non-native species, occupying most of the shallow water of the lake. For example, several of the lakes upstream on the Tippecanoe River, Big and Little Barbee Lakes, Sawmill Lake, and Webster

Lake, support plant communities very similar to that noted in Little Chapman Lake. In contrast, the relative lack of plant growth in many shallow portions of Big Chapman Lake, its healthy stands of emergent bulrush, and its greater species diversity set this lake apart from other lakes in the region.

The presence of Eurasian water milfoil in each of the lakes is of concern, but it is not uncommon for lakes in the region. Eurasian water milfoil is an aggressive, non-native species. It often grows in dense mats excluding the establishment of other plants. For example, once the plant reaches the water's surface, it will continue growing horizontally across the water's surface. This growth pattern has the potential to shade other submerged species preventing their growth and establishment. In addition, Eurasian water milfoil does not provide the same habitat potential for aquatic fauna as many native pondweeds. Its leaflets serve as poor substrate for aquatic insect larva, the primary food source of many panfish.

Eurasian water milfoil, along with curly leaf pondweed, was observed in every lake in Kosciusko County in 1997 (White, 1998a). Moreover, the species absence was only documented in seven lakes in the 15 northern counties in Indiana. These 15 counties include all of the counties in northeastern Indiana where most of Indiana's natural lakes are located. Of the northern lakes receiving permission to treat aquatic plants in 1998, Eurasian water milfoil was listed as the primary target in those permits (White, 1998b).

Two other exotic species were noted during the plant survey: purple loosestrife, an emergent, and spiny naiad, a submerged species. Purple loosestrife is an aggressive species introduced to this country from Eurasia for use as an ornamental garden plant. Like Eurasian water milfoil, purple loosestrife has the potential to dominate habitats, in this case wetland and shoreline communities, excluding native plants. This loss of diversity lowers the habitat quality for waterfowl and aquatic insects. Spiny naiad was also introduced from Eurasia. Unlike purple loosestrife and Eurasian water milfoil, spiny naiad is an annual, making management of the species more difficult in some respects. Fortunately, spiny naiad is also less invasive than the other two species, making management less of a concern.

The plant communities reflect the respective productivities of the two lakes. Nutrient and water clarity measurements in Big Chapman Lake suggest the lake is mesotrophic or nearly oligotrophic in nature (See the In-Lake Sampling Section). Conversely, measurements in Little Chapman Lake place the lake in the eutrophic category. As will be described later, mesotrophic lakes support fewer rooted plants than eutrophic lakes. The two lakes fit these definitions well.

The low productivity of Big Chapman Lake may protect it from developing a widespread Eurasian water milfoil population. In a review of research on Eurasian water milfoil, Smith and Barko (1990) found that the species is more prevalent in slightly eutrophic lakes compared to more oligotrophic lakes. They noted that, in less productive lakes, Eurasian water milfoil dominated only in areas with nutrient rich substrates. This mirrors the situation in Big Chapman Lake. Eurasian water milfoil dominates in the channels and along the eastern shoreline where nutrient rich substrate is likely. In other portions of the lake where the substrate consists of marl and sand, Eurasian water milfoil is either not present or if present, not dominant. In particular, the Eurasian water milfoil present in these areas did not top out a second time as would be expected in dense, nuisance Eurasian water milfoil patches. (A second topping out of Eurasian water milfoil was noted along the eastern shoreline.)

Despite the fact that Big Chapman Lake supports fewer rooted aquatic plants than many lakes in the region, Chapman Lakes residents' views regarding the rooted plants are similar to those expressed by residents on other nearby lakes. The resident survey revealed that macrophytes are seen as a significant problem on the lakes. Sixty-five percent of the survey respondents reported an accumulation of rooted plants in their area of the lake. Most respondents noting this accumulation believe it has occurred over the past ten years. When asked whether the boat population, weeds (macrophytes), runoff, or zebra mussels are the lakes' biggest problems, 67% of the respondents checked weeds as the biggest problem. In an opened ended section of the survey, 30% of the respondents listed rooted plants as most bothersome to them on the lakes. The survey was also analyzed to determine if there is any difference in opinion between the lakes. (i.e., Are residents on Little Chapman more likely to report a problem with rooted plants than those on Big Chapman?) No differences were found. Unhappiness with the rooted plants in the lakes appears to be spread evenly amongst the residents of the two lakes.

The historical aerial photographs (Appendix 5) indicate a plant population very similar in coverage to the one observed today existed at least 60 years ago, prior to heavy residential development around the lakes. While the photographs show the presence of rooted plants, they cannot provide information regarding the species composition. One reason for the perceived increase in the amount of rooted plants in Big Chapman may be a shift in species composition over the years from native species, which do not often reach nuisance levels to exotics such as Eurasian water milfoil, which can grow very densely. Species identification cannot be made from the aerial photographs, but it is unlikely that Eurasian water milfoil was a part of the Chapman Lakes' plant community in 1938. (Biologists estimate the plant was introduced in the United States in the 1940's or 1950's.) An increase in density of rooted plants may give the appearance of increased coverage of rooted plants.

The disparity between lake residents' perception and the current condition of Big Chapman Lake may also be the result of lake users not being able to utilize the lake as they wish. When heaviest plant growth occurs in the same area that most residents would like to use for boating, residents are more likely to report rooted plant problems. Lake users may not notice vegetation problems when desired boating areas are more sparsely vegetated and heavily vegetated areas are located in more remote portions of the lake. On Big Chapman Lake, the heaviest plant growth was observed in the channels and along the eastern shoreline. Thus, eastern shoreline and channels residents must battle the plants to obtain the desired use of the lake. This may leave them with the perception that rooted plants are a widespread problem rather than an isolated one.

Aquatic Plant Management

Based on the discussion above, development of an aquatic plant management plan for the two lakes is strongly recommended. The plan would identify long term goals for plant management while considering the varied needs of all lake users and how rooted plants in the lakes affect these needs. A management plan tailored for the Chapman Lakes should include the following:

1. Recognition of the fact that the two lakes support different types of plant communities and that these communities exist within lakes exhibiting different water chemistries.

2. An educational program explaining the beneficial roles rooted aquatic plants play in healthy lake ecosystems and noting the presence of most of these plants is natural. The program should include information on which species are native and which are exotic and why the control of exotics is important. The program should also explore the impacts human activities, such as boating or lawn fertilizer use, have on aquatic plants. For example, boaters who clean their propellers in the lake should be encouraged to remove cut plant material from the lake rather than leave it there to decay or (if Eurasian water milfoil) to revegetate into a new plant.

3. Identification of the desired uses of the lake and the locations of these uses. This will help direct what type of management techniques should be utilized in each area of the lake. For example, in areas of the lake where fishing is the desired use should be managed to promote the establishment of a healthy, native plant community. In areas targeted for recreational use, such as the channel areas where lake residents want to be able to navigate their boats, more aggressive, control-type techniques should be utilized. Some uses, such as fishing, are dependent upon the type of plant species present. For these uses, lake residents must also identify which plant species they want present and in what quantity. For example, as noted in the ecological roles section above, fish species have differing preferences for amount of rooted plant coverage in a lake. Thus, anglers must identify which fish species they most prefer and manage the aquatic plant community accordingly. When identifying desired uses of a particular area, residents should also consider the species composition currently existing in the area. This will help in evaluating the cost of the desired level of management of specific areas.

4. A focus on Eurasian water milfoil. For reasons noted above, Eurasian water milfoil is undesirable in a lake ecosystem. It is a nuisance species and can prevent the establishment of native rooted plants, which are preferred by wildlife. Management of Eurasian water milfoil is difficult but important.

5. Preference given to management techniques that remove plant material from the lakes, particularly in Little Chapman Lake where internal loading accounts for over a third of the total phosphorus load to the lake. Dead plant material that is left in the lakes contributes nutrients to the water as it decays. The decomposition process also utilizes oxygen creating a reducing environment in the lake's bottom layers, which in turn helps liberate nutrients that are chemically tied to the lake sediment. Management techniques that remove plant material include harvesting (both mechanical and manual), drawdown (provided dead plant material is removed), and limited dredging. Mechanical harvesting should only be used with extreme caution on Big Chapman. Because Eurasian water milfoil can reproduce by fragmentation coupled with the fact that the species is not currently at nuisance levels throughout the lake, the risk of harvesting may outweigh the benefits.

6. Incorporation with a larger watershed management plan that includes efforts to reduce sediment loads from the watershed. In addition to the manmade channels, plant growth and particularly Eurasian water milfoil growth is most severe where inlets from the watershed have deposited nutrient-rich substrate on which nuisance populations of rooted plants have become established. Reducing or eliminating this sediment load will ultimately reduce the potential habitat for rooted plants.

Several aquatic plant management techniques are available to assist lake residents in managing rooted plant populations. To provide lake residents with a better understanding of the range of techniques available, several of these are listed below. Not all of these techniques are recommended or even feasible on Chapman Lake. Any plan developed for the Chapman Lakes plan should focus on the objectives outlined above. A good plant management plan often utilizes different techniques in different parts of a lake to adjust for specific lake characteristics as well as lake users' needs.

Regardless of which techniques are utilized to manage the rooted plant community, it is important to remember that rooted plants are a vital part of a healthy functioning lake ecosystem. Complete eradication of rooted plants is neither desirable nor feasible. A good plant management plan will reflect these facts.

Chemical control

Herbicides are the most traditional means of controlling aquatic vegetation. Herbicides vary in their specificity to given plants, method of application, residence time in the water and the use restrictions for the water during and after treatments. Herbicides (and algalcides; chara is an algae) that are non-specific and require whole lake applications to work are generally not recommended. Such herbicides can kill non-target plant and sometimes even fish species in a lake. Costs of an herbicide treatment vary from lake to lake depending upon the type of plant species present in the lake, the size of the lake, access availability to the lake, the water chemistry of the lake, and other factors. Typically, in northern Indiana costs for treatment range from $275 to $300 per acre ($680 to $750 per hectare, Jim Donahoe, Aquatic Weed Control, personal communication).

While providing a short-term fix to the nuisances caused by aquatic vegetation, chemical control is not a lake restoration technique. Herbicide and algalcide treatments do not address the reasons why there is an aquatic plant problem, and treatments need to be repeated each year to obtain the desired control. In addition, some studies have shown that long-term use of copper sulfate (algalcide) has negatively impacted some lake ecosystems. Such impacts include an increase in sediment toxicity, increased tolerance of some algae species, including some blue-green (nuisance) species, to copper sulfate, increased internal cycling of nutrients and some negative impacts on fish and other members of the food chain (Hanson and Stefan, 1984 cited in Olem and Flock, 1990).

Past use on the Chapman Lakes

No lake-wide chemical control program exists for the Chapman Lakes. Weed Patrol of Elkhart has treated various channels on the lakes in the past several years. They have never done any lake-front treatments, with the exception of the Eurasian water milfoil bed at the mouth of Arrowhead drain. Weed Patrol uses a variety of products to treat the vegetation. They use Reward once every year and copper sulfate and Sidekick 2-3 times per year. They utilize trace amounts of granular 2,4-D on the Eurasian water milfoil bed at the mouth of Arrowhead drain. Weed Patrol also uses trace amounts of granular Hydrosol 191, Aquasol-K, and Cutrine+.

Effectiveness
Table 28 is a guide for common herbicides and their effectiveness in treating the dominant macrophytes found in Indiana lakes. This table is general in nature. While the table rates the chemical as effective vs. non-effective, some chemicals are obviously more effective than others. The effectiveness of any chemical often depends upon the water chemistry of the lake to which it is applied. Any chemical herbicide treatment program should always be developed with the help of a certified applicator who is familiar with the water chemistry of a targeted lake. In addition, application of a chemical herbicide may require a permit from the Indiana Department of Natural Resources, depending on the size and location of the treatment area. Information on permit requirements is available from the DNR Division of Fish and Wildlife or conservation officers.

TABLE 28: Common Herbicides and Their Effectiveness.

Species	Diquat	Endothal	2,4 D	Fluridone
Eurasian water milfoil	M	M	E	E
Curly leaf pondweed	E	E	N	E
Other pondweeds	E	E	-	E*
Coontail	E	E	E	E
Elodea	E	M	N	E
Naiads	E	E*	E*	M

* Depends on species
E = effective
N = non effective
M = mixed results
Table based on information from Olem and Flock, 1990, Westerdahl and Getsinger, 1988, Pullman, 1992 and SePro, 1999.

Mechanical Harvesting
Harvesting involves the physical removal of vegetation from lakes. Harvesting should be viewed as a short-term management strategy. Like chemical control, harvesting needs to be repeated yearly and sometimes several times within the same year. (Some carry-over from the previous year has occurred in certain lakes.) Despite this, harvesting is often an attractive management technique because it can provide lake users with immediate access to areas and activities that have been affected by excessive plant growth. Mechanical harvesting is also beneficial in situations where removal of plant biomass will improve a lake's water chemistry. (Chemical control leaves dead plant biomass in the lake to decay and use up valuable oxygen.)

Macrophyte response to harvesting often depends upon the species of plant and particular way in which the management technique is performed. Pondweeds, which rely on sexual reproduction for propagation, can be managed successfully through harvesting. However, many harvested plants, especially milfoil, can re-root or reproduce vegetatively from the cut pieces left in the water. Plants harvested several times during the growing season, especially late in the season, often grow more slowly the following season (Cooke et al., 1993). Harvesting plants at their roots is usually more effective than harvesting higher up on their stems (Olem and Flock, 1990). This is especially true with Eurasian water milfoil and curly leaf pondweed. Benefits are also derived if the cut plants and the nutrients they contain are removed from the lake. Harvested vegetation that is cut and left in the lake ultimately decomposes, contributing nutrients and consuming oxygen.

The cost of the harvester is typically the largest single outlay of money. Depending upon the capacity of the harvester, costs can range from $3,500 to over $100,000 (Cooke et al., 1993). Other costs associated with harvesting include labor, disposal site availability and proximity, amortization rate, size of lake, density of plants, reliability of the harvester, and other factors. Depending upon the specific situation, harvesting costs can range up to $650 per acre ($1,600 per hectare, Prodan, 1983; Adams, 1983). Estimated costs of the mechanical harvesting program at Lake Lemon in Bloomington, Indiana averaged $267 per acre ($659 per hectare, Zogorski et al., 1986). In general, however, excluding the cost of the machine, the cost of harvesting is comparable to that for chemical control (Cooke et al., 1993, Olem and Flock, 1990). Hand-harvesting equipment is also available for smaller areas around piers at a cost of $50-$1,500 (McComas, 1993).

As stated above harvesting should be used with caution on Big Chapman Lake. Small fragments of Eurasian water milfoil broken off from the plant are capable of sprouting roots and becoming established as an individual plant. Harvesting creates many small fragments of plants despite vigilant efforts to capture all cut plant material. On Big Chapman Lake where nuisance levels of Eurasian water milfoil exist only in the channels and along the eastern shoreline of Big Chapman Lake, the benefits derived from harvesting (reduction of plant density and removal of potential source of nutrients) may not outweigh the risks of spreading the species throughout the lake. While the chance of spreading may be limited by the relatively low productivity of the lake already, the potential still exists, making other management techniques more attractive at this time.

Drawdown

Lake level drawdown can be used as a macrophyte control technique or as an aid to other lake improvement techniques. This technique requires the ability to discharge water from a lake through an outlet structure or dam. Drawdown can be used to provide access to dams, docks, and shoreline stabilizing structures for repairs; to allow dredging with conventional earthmoving equipment; and to facilitate placement of sediment covers.

As a macrophyte control technique, drawdown is recommended in situations where prolonged (one month or more) dewatering of sediments is possible under conditions of severe heat or cold and where susceptible species are the major nuisances. Eurasian water milfoil control for example, apparently requires three weeks or longer of dewatering prior to a one-month freezing period (Cooke, 1980). Cooke (1980) classifies 63 macrophyte species as decreased, increased, or unchanged after drawdown. One must note the presence of resistant species as well as susceptible species, since resistant species can experience a growth surge after a successful drawdown operation.

Macrophyte control during drawdown is achieved by destroying seeds and vegetative reproductive structures (e.g., tubers, rhizomes) via exposure to drying or freezing conditions. To do so, complete dewatering and consolidation of sediments is necessary. Dewatering may not be possible in seepage lakes.

There are a number of other benefits to lakes and reservoirs from drawdown. Game fishing often improves after a drawdown because it forces smaller fish (bluegill) out of the shallow areas and concentrates them with the predators (bass). This decreases the probability of stunted fish and increases the winter growth of the larger game fish. Drawdown has also been used to consolidate loose, flocculent sediments that can be a source of turbidity in lakes. Dewatering compacts the sediments, and they remain compacted after re-flooding (Born et al. 1973 and Fox et al. 1977).

A final consideration in implementation of lake level drawdown is season; winter or summer are usually chosen because they are most severe. According to Cooke (1980), “it is not clear whether drawdown and exposure of lake sediments to dry, hot conditions is more effective than exposure to dry, freezing conditions.” One factor to consider is which season is most rigorous. Advantages of winter drawdown include less interference with recreation, ease of spring versus autumn refill, and no invasion of terrestrial plants. Sediment dewatering is easier in summer. Additionally, summer drawdown may also create opportunities for establishing *native* shoreline communities.

In Murphy Flowage, a 180-acre (73 ha) reservoir in Wisconsin, a five-foot drawdown from mid-October to March greatly reduced the presence of aquatic macrophytes the following growing season. Milfoil was reduced from 20 to <2.5 acres (8 ha to <1 ha), spatterdock was reduced from 42 to 12.5 acres (17 ha to 5 ha), and pondweeds were reduced from 114 to 7.5 acres (46 ha to 3 ha) (Beard 1973).

Drawdowns are not possible on all lakes. In lakes and reservoirs that do not have legal lake levels, manipulation of water level is possible without obtaining permission from regulatory agencies. Any effort to raise or lower a legally established lake level requires that the legal level be changed. This process can be quite time consuming, taking up to a year for a decision to be made. In addition, drawdowns are not physically practical on lakes that lack water control structures. On lakes where drawdowns are feasible, however, they offer a low cost management technique that does not require the introduction of chemicals or machinery.

Drawdown may be possible on the Chapman Lakes. The appropriate season for drawdown must be based the targeted plant species. In a literature review by Cooke (1993), winter drawdowns appear to have the most success in managing Eurasian water milfoil. Any drawdown efforts should be coordinated with fisheries biologists from the IDNR to prevent any negative impacts to the lakes’ fish communities. Legal and regulatory obligations must be explored as well.

Biological Control

Grass Carp

Grass carp are the most well known species used for biological control of aquatic plants. Grass carp are an exotic fish species brought to this country from Malaysia. These carp feast on a wide range of aquatic plants; *Elodea* spp. and pondweeds are among their favorites. Unfortunately, grass carp do not like milfoil and will only eat milfoil when their favorite foods are depleted. Over the course of time, grass carp typically will devour all the plants in a lake, leaving none for fish habitat or bank/substrate stabilization. In addition, grass carp may negatively alter resident fish communities, increase nutrient release from sediments promoting algal blooms, and increase the turbidity of lakes. For these reasons, the use of grass carp in public waters is banned in 18 states including Indiana. Carp stocked in private ponds must be certified as genetically triploid and must have no possible access to other waterways.

Insects

The use of specific insect species in controlling aquatic plant growth has been investigated as well. Much of this research has concentrated on aquatic plants that are common in southern lakes such as alligator weed, hydrilla, and water hyacinth. Cooke et al. (1993) also points to four different species that may reduce Eurasian water milfoil infestations: *Triaenodes tarda*, a caddisfly, *Cricotopus myriophylii*, a midge, *Acentria nivea*, a moth and *Litodactylus leucogaster*, a weevil.

Eurasian Water Milfoil

Recent research suggests another alternative: *Euhrychiopsis lecontei*, a weevil. *E. lecontei* has been implicated in a reduction of Eurasian water milfoil in several Northeastern and Midwestern lakes (EPA, 1997). *E. lecontei* weevils reduce milfoil biomass by two means: one, both adult and larval stages of the weevil eat different portions of the plant and two, tunneling by weevil larvae cause the plant to lose buoyancy and collapse, limiting its ability to reach sunlight. Techniques for rearing and releasing the weevil in lakes have been developed and under appropriate conditions, use of the weevil has produced good results in reducing Eurasian water milfoil.

Cost effectiveness and environmental safety are among the advantages to using the weevil rather than traditional herbicides in controlling Eurasian water milfoil (Christina Brant, EnviroScience, personal communication). Cost advantages include the weevil's low maintenance and long-term effectiveness versus the annual application of an herbicide. In addition, use of the weevil does not have use restrictions that are required with some chemical herbicides. Use of the weevil has a few drawbacks. The most important one to note is that reductions in Eurasian water milfoil are seen over the course of several years in contrast to the immediate response seen with traditional herbicides. Therefore, lake residents need to be patient. While the Chapman Lakes possess large stretches of natural shoreline, which the weevils require for over-wintering, these stretches are not adjacent to areas in which Eurasian water milfoil management is needed. Thus, the lakes may not be good candidates for weevil release.

Purple Loosestrife

Biological control may also be possible for controlling the growth and spread of the emergent purple loosestrife. Like Eurasian water milfoil, purple loosestrife is an aggressive non-native species. Once purple loosestrife becomes established in an area, the species will readily spread and take over the habitat, excluding many of the native species which are more valuable to wildlife. Conventional control methods including mowing, herbicide applications, and prescribed burning have been unsuccessful in controlling purple loosestrife.

Some control has been achieved through the use of several insects. A pilot project in Ontario, Canada reported a decrease of 95% of the purple loosestrife population from the pretreatment population (Cornell Cooperative Extension, 1996). Four different insects were utilized to achieve this control. These insects have been identified as natural predators of purple loosestrife in its native habitat. Two of the insects specialize on the leaves, defoliating a plant (*Gallerucella calmariensis* and *G. pusilla*), one specializes on the flower, while one eats the roots of the plant (*Hylobius transversovittatus*). Insect releases in Indiana to date have had mixed results. After six years, the loostrife of Fish Lake in LaPorte County is showing signs of deterioration.

Like biological control of Eurasian water milfoil, use of purple loosestrife predators offers a cost-effective means for achieving long-term control of the plant. Complete eradication of the plant cannot be achieved through use of a biological control. Insect (predator) populations will follow the plant (prey) populations. As the population of the plant decreases, so will the population of the insect since their food source is decreasing.

Because of the limited extent of purple loosetrife at the Chapman Lakes, management should focus on hand removal of the species. (This may require educating lake residents in identifying purple loosestrife.) Given the relatively small and scattered distribution of the species, release of a biological control would not be cost effective at this time.

Bottom covers

Bottom shading by covering bottom sediments with fiberglass or plastic sheeting materials provides a physical barrier to macrophyte growth. Buoyancy and permeability are key characteristics of the various sheeting materials. Buoyant materials (polyethylene and polypropylene) are generally more difficult to apply and must be weighted down. Sand or gravel anchors can act as substrate for new macrophyte growth, however. Materials must be permeable to allow gases to escape from the sediments; gas escape holes must be cut in impermeable liners. Commercially available sheets made of fiberglass-coated screen, coated polypropylene, and synthetic rubber are non-buoyant and allow gases to escape, but cost more (up to $66,000 per acre or $163,000 per hectare for materials, Cooke and Kennedy, 1989). Indiana regulations specifically prohibit the use of bottom covering material as a base for beaches.

Due to the prohibitive cost of the sheeting materials, sediment covering is recommended for only small portions of lakes, such as around docks, beaches, or boat mooring areas. This technique may be ineffective in areas of high sedimentation, since sediment accumulated on the sheeting material provides a substrate for macrophyte growth. The IDNR requires a permit for any permanent structure on the lake bottom, including anchored sheeting.

Dredging

Dredging is occasionally used as a means to control aquatic plant growth. Dredging may control aquatic vegetation by two means. First, it removes aquatic vegetation. Second, it may prevent the re-establishment of vegetation by removing the substrate in which vegetation flourished and deepening the lake to a depth at which the sunlight penetration may be too limited or water pressure may be too great to allow for plant growth. Any dredging activities in a freshwater public lake will require permits from the Corps of Engineers, the Indiana Department of Environmental Management (IDEM), and IDNR. Dredging operations are fairly costly with prices ranging from $15,000 to $20,000 per acre ($37,000 to $49,400 per hectare, Jeff Krevda, Dredging Technologies, personal communication). This estimate excludes the costs of transportation to a disposal site and purchase of the disposal site if one is not available for free.

Dredging has several negative ecological impacts associated with it. For example, habitat for many aquatic insects (the macrophytes and top portion of the lake sediment) is removed along with the insects. These insects serve as an important food source to fish, and their removal may harm a lake's fishery. In addition, mechanical dredging resuspends nutrient rich sediments causing algae blooms. It is important to note that the IDNR (Jed Pearson, personal communication) does not encourage dredging areas that have never been dredged before or frequent re-dredging of the same area.

Dredging may be appropriate in some of areas of the two lakes: specifically where Crooked Creek, the Arrowhead Park Drain, and the Highlands Park Drain discharge to the two lakes. These areas were identified during a field survey as areas of sediment accumulation upon which nuisance levels of Eurasian water milfoil have become established. Dredging should only occur after steps have been taken to reduce sediment loads to the lakes. Dredging that occurs before measures are taken will only have to be repeated; in this case, dredging is not a cost effective technique for managing macrophyte growth. The 1999 IDNR Fisheries Survey (Pearson, 1999) supports the need for dredging at the mouth of Crooked Creek.

WATER BUDGET

Inputs of water to Big Chapman Lake are limited to:

1. direct precipitation to the lakes
2. discharge from the inlet streams
3. sheet runoff from land immediately adjacent to the lake
4. groundwater

Water leaves Big Chapman Lake from:

1. discharge from the outlet channel to Little Chapman
2. evaporation
3. groundwater

Inputs of water to Little Chapman Lake are limited to:

1. direct precipitation to the lakes
2. discharge from the inlet streams
3. discharge from Big Chapman Lake
4. sheet runoff from land immediately adjacent to the lake
5. groundwater

Water leaves Little Chapman Lake from:

1. discharge from the outlet channel (Heeter Ditch)
2. evaporation
3. groundwater

There are no discharge gages in the watershed to measure water inputs and the limited scope of this study does not allow for the quantitative determination of annual water inputs or outputs. Therefore, the water budget for Chapman Lakes was estimated from other records.

- Direct precipitation to the lakes can be calculated from mean annual precipitation falling directly on the lakes' surface.
- Runoff from the lakes' watershed can be estimated by applying runoff coefficients. A runoff coefficient refers to the percentage of precipitation that occurs as surface runoff, as opposed to that which soaks into the ground. Runoff coefficients may be estimated by comparing discharge from a nearby gaged watershed of similar land and topographic features, to the total amount of precipitation falling on that watershed. The nearest gaged watershed is a U.S.G.S. gaging station on Walnut Creek near Warsaw, Indiana (Stewart et al., 1999). The 30-year (1970–1999) mean annual runoff for this watershed is 12.8 inches. With annual precipitation of 35.52 inches (Staley, 1989), this means that 36 % of the rainfall falling on this watershed runs off on the land surface.
- No groundwater records exist for the lake, so it was assumed that groundwater inputs equal outputs or groundwater effects were insignificant compared to surface water impacts.
- Evaporation losses were estimated by applying evaporation rate data to the lakes. Evaporation rates are determined at six sites around Indiana by the National Oceanic and Atmospheric Administration (NOAA). The nearest site to the Chapman Lakes is located in Valparaiso, Indiana. Annual evaporation from a 'standard pan' at the Valparaiso site averages 28.05 inches per year. Because evaporation from the standard pan overestimates evaporation from a lake by about 30%, the evaporation rate was corrected by this percentage to yield an estimated evaporation rate from the lake surface of 19.95 inches per year. Multiplying this rate times the surface area of each lake yields an estimated volume of evaporative water loss from Chapman Lakes.
- Finally, the output from Big Chapman Lake represents an additional source of water to Little Chapman Lake.

Water budgets for Big and Little Chapman lakes are shown in Tables 29 and 30. When the volume of water flowing out of Big Chapman Lake is divided by the lake's volume, a *hydraulic residence time* of 2.07 years results. This means that on average, water entering the lake stays in the lake for 2.07 years before it leaves. In other words, the Big Chapman's volume is replaced by 'new' water about once every 2 years. This hydraulic flushing rate is pretty average for lakes in this part of the country. In a study of 95 north temperate lakes in the U.S., the mean hydraulic residence time for the lakes was 2.12 years (Reckhow and Simpson, 1980).

Because Little Chapman Lake is downstream from Big Chapman Lake, it not only receives runoff from its own watershed, but also receives the discharge from Big Chapman Lake. This larger volume of water and the smaller overall volume of Little Chapman Lake means that Little Chapman's hydraulic residence time is a very short 0.35 years. This lake's volume is replaced about three times each year.

TABLE 29. Water Budget Calculations for Big Chapman Lake.

Big Chapman Lake watershed size (ac)	2218
Mean Watershed Runoff (ac-ft/yr)	2368
Lake Volume (ac-ft)	6257
Runoff Estimates	
Closest gaged stream	Walnut Cr. near Warsaw
Stream watershed (mi2)	19.6
Stream watershed (acres)	12544
Mean annual Q (cfs)	18.5
Mean annual Q (ac-ft/yr)	13393
Mean ppt (in/yr)	35.52
Mean watershed ppt (ac-ft/yr)	37130
Watershed C	0.36071
Evaporation Estimates	
Pan evaporation (in/yr)	28.05
Pan evaporation coefficient	0.70
Lake Surface Area (acres)	499
Estimated lake evaporation (ac-ft)	816
Direct precipitation to lake (ac-ft)	1477
Water Budget Summary	
Direct precipitation to lake (ac-ft)	1477
Runoff from watershed (ac-ft)	2368
Evaporation (ac-ft)	816
Total Lake Output (ac-ft)	3029
Hydraulic Residence Time (yr)	**2.07**

TABLE 30. Water Budget Calculations for Little Chapman Lake.

Little Chapman Lake watershed size (ac)	2327
Mean Watershed Runoff (ac-ft/yr)	2485
Lake Volume (ac-ft)	1977
Runoff Estimates	
Closest gaged stream	Walnut Creek near Warsaw
Stream watershed (mi2)	19.6
Stream watershed (acres)	12544
Mean annual Q (cfs)	18.5
Mean annual Q (ac-ft/yr)	13393
Mean ppt (in/yr)	35.52
Mean watershed ppt (ac-ft/yr)	37130
Watershed C	0.36071
Evaporation Estimates	
Pan evaporation (in/yr)	28.05
Pan evaporation coefficient	0.70
Lake Surface Area (acres)	139
Estimated lake evaporation (ac-ft)	227
Direct precipitation to lake (ac-ft)	411
Water Budget Summary	
Direct precipitation to lake (ac-ft)	411
Runoff from watershed (ac-ft)	2485
Evaporation (ac-ft)	227
Discharge from Big Chapman	3029
Total Lake Output (ac-ft)	5697
Hydraulic Residence Time (yr)	**0.35**

PHOSPHORUS BUDGET

Since phosphorus is the limiting nutrient in both Big and Little Chapman lakes, a phosphorus model was used to estimate the dynamics of this important nutrient in these lakes. With its role as the limiting nutrient, phosphorus should be the target of management activities to lower the biological productivity of Chapman Lakes.

The limited scope of this LARE study did not allow for the outright determination of phosphorus inputs and outputs. Therefore, a standard phosphorus model was utilized to estimate the phosphorus budget. Reckhow et al. (1980) compiled phosphorus loss rates from various land use activities as determined by a number of different studies and calculated phosphorus export coefficients for each land use in the watershed. The mid-range estimates of these phosphorus export coefficient values were used for all watershed land uses except row-crop agriculture, where slightly lower range estimates were used to reflect the extensive use of agricultural best management practices within Kosciusko County (Table 31). Phosphorus export coefficients are expressed as kilograms of phosphorus lost per hectare of land per year. They are multiplied by the amount of land in each of the land use categories to derive an estimate of annual phosphorus export (as kg/year) for each land use per watershed (Table 32).

TABLE 31. Phosphorus Export Coefficients (units are kg/hectare except the septic category, which are kg/capita-yr).

Estimate Range	Agriculture	Forest	Precipitation	Urban	Septic
High	3.0	0.45	0.6	5.0	1.8
Mid	0.40-1.70	0.15-0.30	0.20-0.50	0.80-3.0	0.4-0.9
Low	0.10	0.2	0.15	0.50	0.3

Source: Reckhow and Simpson (1980)

Direct phosphorus input via precipitation to the lakes was estimated by multiplying mean annual precipitation in Kosciusko County (0.9 m/yr) times the surface area of each lake times a typical phosphorus concentration in Indiana precipitation (0.03 mg/L). For septic system inputs, the number of permanent, summer seasonal, and short seasonal homes on each lake was multiplied times an average of 3 residents per home to calculate per capita years. We used a mid-range phosphorus export of 0.5 kg/capita-yr and a soil retention coefficient of 0.75 (this assumes that the drain field retains 75% of the phosphorus applied to it).

Because Big Chapman Lake drains into Little Chapman, it is the source of a significant mass of phosphorus. To estimate this quantity, the mean, volume-weighted phosphorus concentration in Big Chapman Lake at the time of our sampling (8/7/00) was calculated and multiplied times the water discharge from that lake. This yielded an estimated discharge of 138 kilograms per year of phosphorus from Big Chapman into Little Chapman.

The results, shown in Tables 32 and 33, yielded an estimated 693 kg of phosphorus loading to Big Chapman Lake from its watershed and from precipitation annually. The total phosphorus loading to Little Chapman Lake from all external sources was estimated to be nearly 898 kg of phosphorus per year with 138 kg of this phosphorus being passed through Big Chapman into Little Chapman.

The relationships among the primary parameters that affect a lake's phosphorus concentration can be examined by using a phosphorus-loading model such as the widely used Vollenweider (1975) model. Vollenweider's empirical model says that the concentration of phosphorus ([P]) in a lake is proportional to the areal phosphorus loading (L, in g/m^2 lake area - year), and inversely proportional to the product of mean depth ($\bar{z}$) and hydraulic flushing rate (ρ) plus a constant (10):

$$[P] = \frac{L}{10 + \bar{z}\rho}$$

During the August 7, 2000 sampling of the Chapman Lakes, the mean volume weighted phosphorus concentration in Big Chapman was 0.037 mg/L and 0.113 mg/L for Little Chapman.

TABLE 32. Phosphorus Model Results for Big Chapman Lake.

Phosphorus Loading - Lake Response Model				
LAKE:	Big Chapman		**DATE:**	1/30/2001
COUNTY:	Kosciusko			
STATE:	Indiana			
INPUT DATA		**Unit**		
Area, Lake	499	acres		
Volume, Lake	6257	ac-ft		
Mean Depth	12.5	ft		
Hydraulic Residence Time	2.07			
Flushing Rate	0.48	1/yr		
Mean Annual Precipitation	0.90	m		
[P] in precipitation	0.03	mg/l		
[P] in epilimnion	0.030	mg/l		
[P] in hypolimnion	0.082	mg/l		
Volume of epilimnion	5403	ac-ft		
Volume of hypolimnion	854	ac-ft		
Land Use (in watershed)	**Area**	--------	**P-export Coefficient**	
Row Crop	1001.0	hectare	0.30	kg/ha-yr
Pasture	119.0	hectare	0.20	kg/ha-yr
Forest	259.0	hectare	0.20	kg/ha-yr
Urban	96.7	hectare	0.90	kg/ha-yr
Shrubland	275.0	hectare	0.20	
Septic Systems	--------	--------	0.50	kg/ha-yr
	1750.70			
Other Data				
Soil Retention coefficient	0.75	--------		
# Permanent Homes	287	homes		
Use of Permanent Homes	1.0	year		
# Seasonal Homes	122	homes		
Use of Seasonal Homes	0.25	year		
# Seasonal Homes	39	homes		
Use of Seasonal Homes	0.09	year		
Avg. Persons Per Home	3	persons		
OUTPUT				
P load from watershed	517.93	kg/yr		
P load from precipitation	54.65	kg/yr		
P load from septic systems	120.38	kg/yr		
Total External P load	692.96	kg/yr		
Areal P loading	0.343	g/m^2-yr		
Predicted P from Vollenweider	0.029	mg/l		
Back Calculated L total	0.439	g/m2-yr		
Estimation of L internal	0.096	g/m2-yr		
% of External Loading	78.1	%		
% of Internal Loading	21.9	%		

TABLE 33. Phosphorus Model Results for Little Chapman Lake.

Phosphorus Loading - Lake Response Model				
LAKE:	Little Chapman		**DATE:**	1/30/2001
COUNTY:	Kosciusko			
STATE:	Indiana			
INPUT DATA		**Unit**		
Area, Lake	139	acres		
Volume, Lake	1977	ac-ft		
Mean Depth	14.2	ft		
Hydraulic Residence Time	0.35			
Flushing Rate	2.86	1/yr		
Mean Annual Precipitation	0.90	m		
[P] in precipitation	0.03	mg/l		
[P] in epilimnion	0.079	mg/l		
[P] in hypolimnion	0.217	mg/l		
Volume of epilimnion	1491	ac-ft		
Volume of hypolimnion	486	ac-ft		
Land Use (in watershed)	**Area**	--------	**P-export Coefficient**	
Row Crop	1703.8	hectare	0.30	kg/ha-yr
Pasture	21.1	hectare	0.20	kg/ha-yr
Forest	190.3	hectare	0.20	kg/ha-yr
Urban	125.1	hectare	0.90	kg/ha-yr
Shrubland	155.6	hectare	0.20	
Septic Systems	--------	--------	0.50	kg/ha-yr
Other Data				
Soil Retention coefficient	0.75	--------		
# Permanent Homes	112	homes		
Use of Permanent Homes	1.0	year		
# Seasonal Homes	48	homes		
Use of Seasonal Homes	0.25	year		
# Seasonal Homes	15	homes		
Use of Seasonal Homes	0.09	year		
Avg. Persons Per Home	3	persons		
OUTPUT				
P load from watershed	697.13	kg/yr		
P load from precipitation	15.22	kg/yr		
P load from septic systems	47.01	kg/yr		
P load from Big Chapman	138.24	kg/yr		
Total External P load	897.60	kg/yr		
Areal P loading	1.596	g/m2-yr		
Predicted P from Vollenweider	0.071	mg/l		
Back Calculated L total	2.528	g/m2-yr		
Estimation of L internal	0.932	g/m2-yr		
% of External Loading	63.1	%		
% of Internal Loading	36.9	%		

It is useful to determine how much phosphorus loading from all sources is required to yield a mean phosphorus concentration of 0.037 mg/L in Big Chapman Lake. Plugging this mean concentration along with the mean depth and flushing rate into Vollenweider's phosphorus loading model and solving for L results in an areal phosphorus loading rate (mass of phosphorus per unit area of lake) of 0.439 g/m^2-yr. This means that in order to get a mean phosphorus concentration of 0.037 mg/L in Big Chapman, a total of 0.439 grams of phosphorus must be delivered to each square meter of lake surface area per year.

Total phosphorus loading (L_T) is composed of external phosphorus loading (L_E) and internal phosphorus loading (L_I). Since L_T = 0.439 g/m^2-yr and L_E = 0.343 g/m^2-yr (calculated from the watershed loading in Table 32), then internal phosphorus loading (L_I) equals 0.096 g/m^2-yr. Thus, internal loading accounts for about 22% of total phosphorus loading to Big Chapman Lake. Using a similar method for Little Chapman Lake yields an internal phosphorus loading rate of 0.932 g/m^2-yr or 37% of total phosphorus loading to the lake.

It is important to check these conclusions that internal phosphorus loading accounts for 22% of total phosphorus loading to Big Chapman Lake and 37% of total phosphorus loading to Little Chapman with the data obtained during the August 7 sampling. There is evidence in Little Chapman that soluble phosphorus is being released from the sediments during periods of anoxia. For example, concentrations of soluble phosphorus in Little Chapman's hypolimnion are 13 times higher than concentrations in the epilimnion (0.013 μg/L vs. 0.173 μg/L). This internal loading can be a major source of phosphorus in many productive lakes. While there is virtually no difference in the epilimnetic and hypolimnetic soluble phosphorus concentrations in Big Chapman Lake, it is very likely that soluble phosphorus is being released from the sediments of this lake as well. Because of the deep photic zone in Big Chapman, it is possible that algae are using the internally-released soluble phosphorus even in the deeper waters.

Another source of internal phosphorus to these lakes could be the fall dieback of rooted macrophytes. These plants obtain the majority of their nutrients from the sediments. In essence, they 'pump' nutrients out of the sediments into their tissues. When the rooted plants die back in the fall, the nutrients contained within their tissues are released back into the water. In Monroe Reservoir, the annual fall senescence of Eurasian watermilfoil alone accounted for up to 24% of phosphorus and 2% of the nitrogen from all nonpoint sources (Landers and Frey, 1980). This release resulted in a massive fall algal bloom in the reservoir. Considering all the rooted plant species in Big and Little Chapman, it is conceivable that they could contribute a significant amount of phosphorus to the lake at the time of fall die-back.

The significance of this areal loading rate is better illustrated in Figure 48 in which areal phosphorus loading is plotted against the product of mean depth times flushing rate. Overlain on this graph is a curve, based on Vollenweider's model, which represent an acceptable loading rate that yields a phosphorus concentration in lake water of 30 ug/L (0.03 mg/L). Big Chapman Lake's areal phosphorus loading rate falls barely into the excessive loading portion of the graph while that for Little Chapman is well above the acceptable line.

This figure can also be used to evaluate management needs. For example, areal phosphorus loading to Big Chapman would have to be reduced to 0.354 g/m^2-yr to yield a mean lake water concentration of 30 µg/L. This represents a reduction in phosphorus mass loading to the lake of 170 kg/yr, a 19% reduction in the current total annual phosphorus mass loading. Although the feasibility of doing so is unlikely, eliminating internal phosphorus loading (193 kg/yr) alone will meet this reduction need and bring total annual phosphorus mass loading to an acceptable level.

For Little Chapman, the task to bring total areal phosphorus loading down to an acceptable level (that which results in [P] = 0.030 mg/L) is much greater. Areal phosphorus loading to Little Chapman would have to be reduced from 2.527 to 0.671 g/m^2-yr to yield an in-lake phosphorus concentration of 0.030 mg/L. This represents a reduction in phosphorus mass loading to the lake of 1044 kg/yr, a 73% reduction in the current total annual phosphorus mass loading. In Little Chapman Lake, internal phosphorus loading (524 kg/yr) accounts for more that one-half of the necessary reduction needed. Phosphorus loading from Big Chapman accounts for another 138 kg/yr. Little Chapman's large watershed size and relatively small volume make phosphorus management more difficult than it is for Big Chapman.

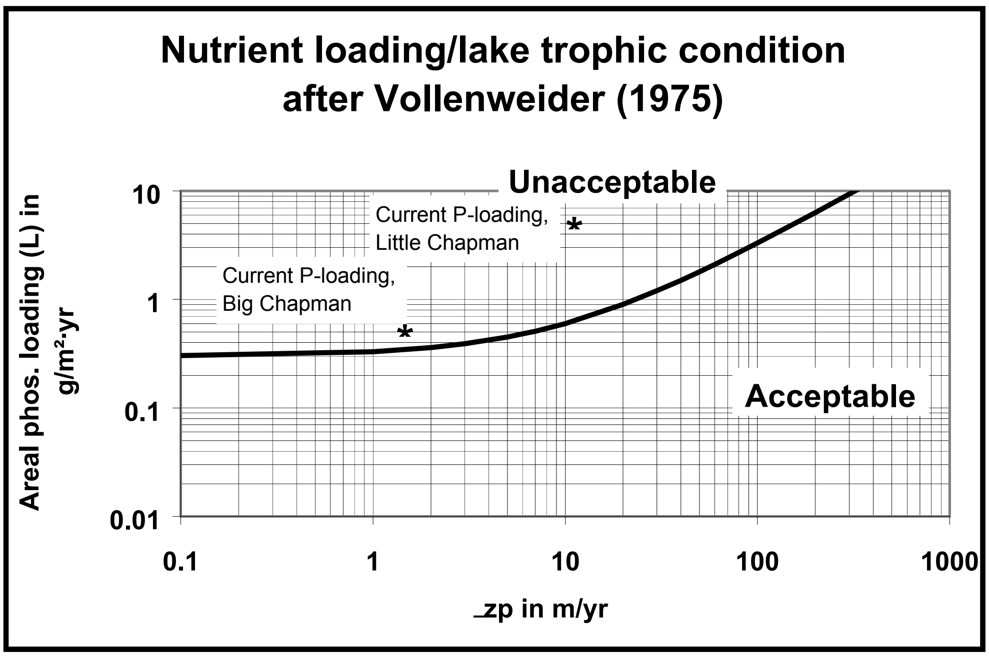


FIGURE 48. Phosphorus loadings to Big and Little Chapman compared to acceptable loadings determined from Vollenweider's model.

WATERSHED MANAGEMENT

The following paragraphs summarize the primary issues faced by each subwatershed or location and describe management techniques that might be utilized to treat the problems. Figure 49 provides a map of locations and areas that can be targeted for management.

Crooked Creek Subwatershed

Much of the Crooked Creek subwatershed is utilized for agricultural purposes. This land use can have an impact on water quality downstream. Runoff from farm fields can contain a variety of pollutants including nutrients (nitrogen and phosphorus), pesticides, sediment, and bacteria (fecal coliforms). Inlet sampling results showed that Crooked Creek delivered the greatest amount of total Kjeldahl nitrogen, ammonia nitrogen, total phosphorus, and total suspended solids to the Chapman Lakes during storm flow conditions. To put the total suspended solids loading in perspective, Crooked Creek's total suspended solids loading rate was an order of magnitude more than that observed for Lozier Creek despite the fact that the Crooked Creek subwatershed is slightly (50 acres or 20 ha) smaller than the Lozier's Creek subwatershed. The Crooked Creek subwatershed also possesses the greatest percentage of potentially highly erodible land (50%). Farming practices on highly erodible lands may exacerbate non-point source pollution.

One way to reduce nutrient and sediment runoff associated with agricultural practices is to remove land from agricultural production. The Conservation Reserve Program (CRP), run by the U.S. Department of Agriculture, is a voluntary, competitive program designed to encourage landowners to establish vegetation on their property in an effort to decrease erosion, improve water quality, or enhance wildlife habitat. Ideal areas for this program include highly erodible lands, riparian zones, and farmed wetlands. Farmers receive cost share assistance for the plantings and annual payments for their land. (See the Appendix 10: Additional Funding for more details on the Conservation Reserve Program.)

Removing land from production and planting it with vegetation has a positive impact on the water quality of lakes in the watershed. In a review of Indiana lakes sampled from 1989 to 1993 for the Indiana Clean Lakes Program, Jones (1996) showed that ecoregions reporting higher percentages of cropland in CRP had lower mean trophic state index (TSI) scores for their lakes. (As described in the In-Lake Sampling Section, a TSI is an indicator of lake productivity or health. Lower TSI scores indicate lower productivity or generally better water quality.)

Removal of land from agricultural production may not be economically feasible in some cases. Conservation tillage offers the potential for reducing erosion without removing the land from production. Conservation tillage requires leaving some portion of the crop on the land after its harvest rather than completely tilling the soil under as is done in conventional tillage. No-till is a type of conservation tillage. Depending upon the type of conservation tillage used, reported decreases in sediment loading to waterways have ranged from 60 to 98 percent and reductions in phosphorus input range from 40 to 95 percent. Reductions of pesticide loadings have also been reported (Olem and Flock, 1990). In the review of Indiana lakes referred to above (Jones, 1996), lower TSI scores were observed in ecoregions with higher percentages of conservation tillage.

Buffer or filter strips and grassed waterways along drainages and riparian zones are also effective Best Management Practices (BMPs) to reduce pollutant input to waterways. Filter strips slow

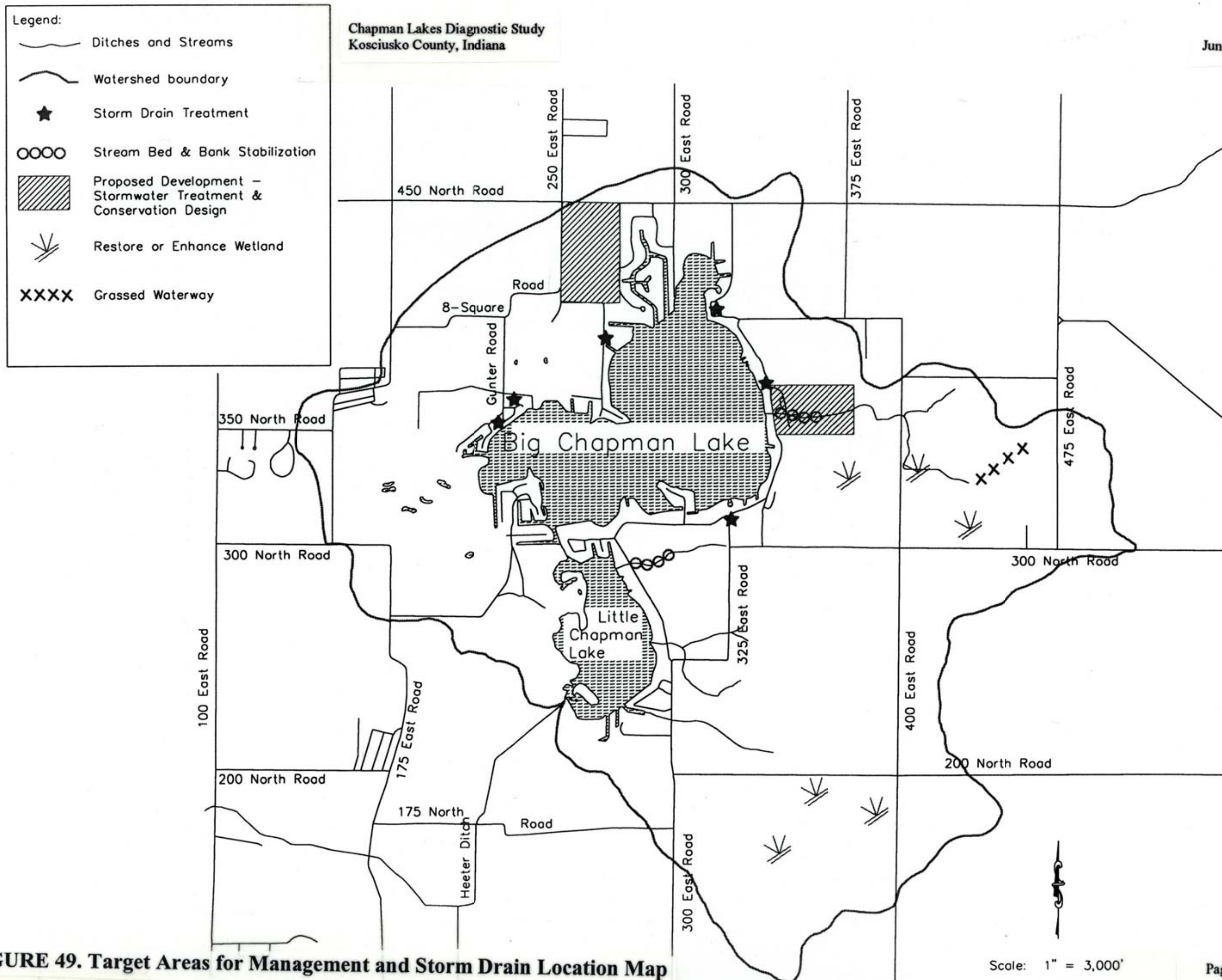


FIGURE 49. Target Areas for Management and Storm Drain Location Map

Source of Base Map: U.S.G.S. 7.5 Minute Topographic Map overland flows from adjacent agricultural areas and reduce flow volume by increasing infiltration of the runoff. Slower runoff velocities and reduced flow volumes lead to decreased erosion downstream. Buffers also help stabilize stream banks. Vegetated strips filter sediments, nutrients, and pesticides from the runoff preventing them from reaching the lakes and streams. Buffer strips can reduce up to 80% of the sediment, 50% of the phosphorus, and 60% of the pathogens in runoff (Conservation Technology Information Center, 2000). A specific area targeted for the establishment of a grassed waterway is the agricultural land at the headwaters of Crooked Creek, north of County Road 300 North and east of Country Road 400 East (Figure 49).

A reduction in sediment delivery to Big Chapman Lake via Crooked Creek may also be achieved by restoring wetlands in the subwatershed. Based on an analysis of hydric soil in the subwatershed, Crooked Creek has suffered the second greatest loss in wetland acreage compared to other subwatersheds (Table 7). This loss of wetland acreage has decreased the storage capacity of the land and increased peak flows of water in Crooked Creek. An increase in peak flows typically leads to increases in channel erosion of both streambed and bank and ultimately to increases in sediment loads to the lakes. A field inspection of Crooked Creek revealed evidence of bed and bank scouring. Large deposition bars in the creek highlight the increased sediment load in Crooked Creek.

It should be noted that agricultural property owners in the Chapman Lakes watershed are already utilizing a variety of conservation methods. As shown on Figure 50, one property owner is participating in the Conservation Reserve Program. Rather than farming the parcel, the property owner planted an herbaceous ground cover. This parcel will be released from the program in 2002. Another property owner has established a grassed waterway at the headwaters of the Arrowhead Park drainage. Other agricultural property owners have expressed an interest in participation in CRP. Several lakeshore property owners purchased 35 acres of agricultural land north of Crooked Creek with the intention of developing it as wildlife habitat. Evidence of conservation tillage was observed in the watershed during field inspections. The Chapman Lakes Conservation Club should consider forming a partnership with agricultural property owners who currently utilize conservation methods. This partnership could sponsor educational forums to educate other agricultural property owners on how conservation methods work and their impact on the Chapman Lakes. This cooperative effort may help increase awareness and participation in conservation programs. Similar outreach efforts in the Upper Tippecanoe watershed have produced positive results (i.e., The Upper Tippecanoe River Hydrologic Unit Area project. Continued outreach is important to the success of any partnership program.

The restoration of wetlands in the Crooked Creek subwatershed could return many of the functions that were lost when these areas were drained. In addition to water storage functions described above, wetlands also operate as nutrient sinks at times, which may decrease nutrient inputs to Crooked Creek. Specific locations where wetland restoration and/or enhancement may be explored include: 1. an agricultural parcel north of County Road 300 North and west of County Road 400 East, 2. an agricultural parcel north of County Road 300 North and east of County Road 400 East, and 3. an agricultural land parcel southeast of 2., north of County Road 300 North and east of County Road 400 East (Figure 49).

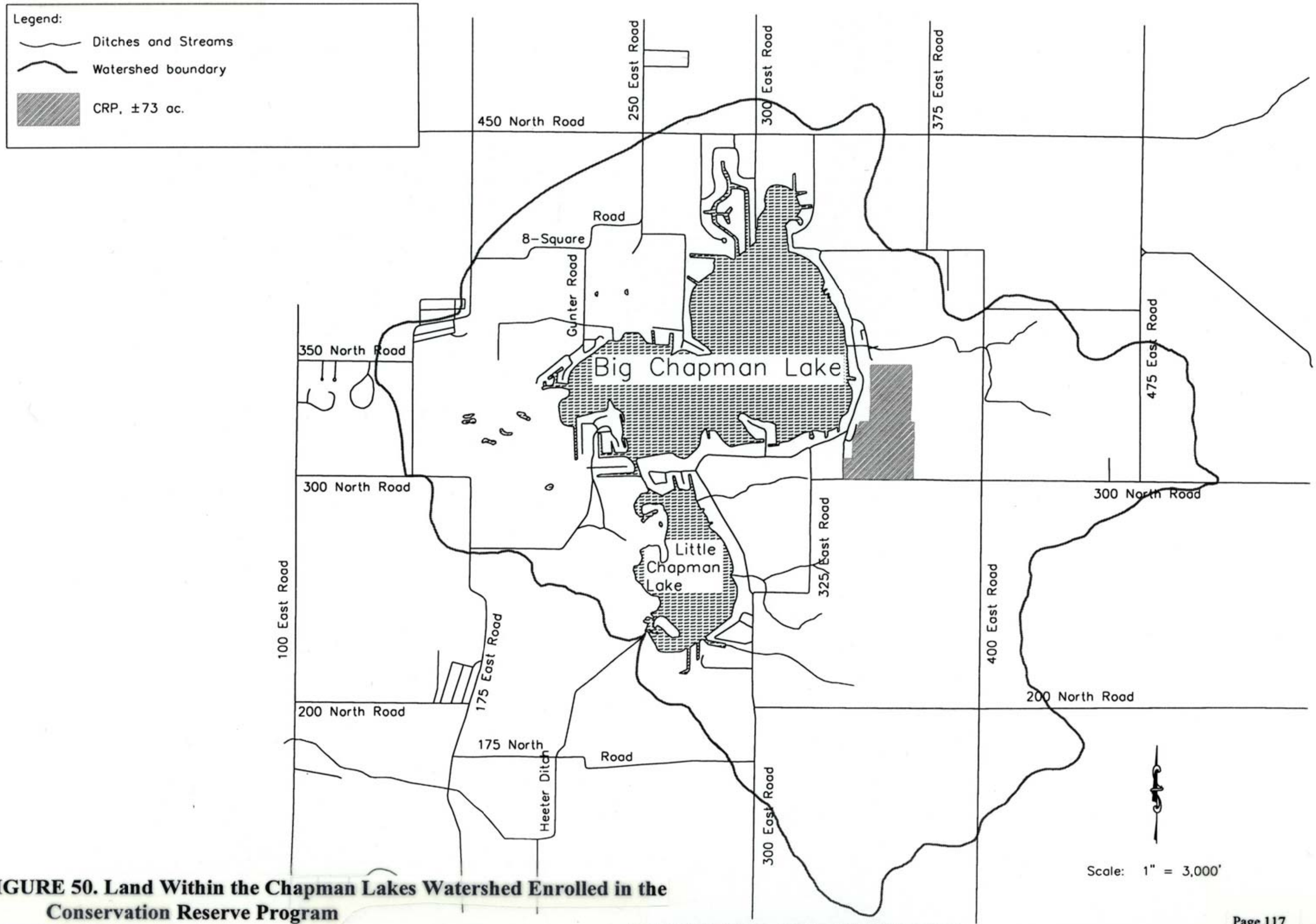


FIGURE 50. Land Within the Chapman Lakes Watershed Enrolled in the Conservation Reserve Program

Wetland restoration in the upper watershed of creeks suffering from increased volumes and peak discharges will help decrease the bed and bank erosion in the creeks. Once the increased volumes and peak flows are decreased, creeks will heal themselves over time. Often it is beneficial to take management steps to help speed the natural healing process. These management steps provide immediate relief to downstream waterbodies receiving the sediment input. Available management techniques include installation of grade controls to stabilize both bed and banks, regrading of banks, installation of erosion control fabric and reseeding of banks, and the installation of cribs walls, live willows stakes and/or biologs along eroded banks. Natural bioengineering techniques are recommended over placement of riprap armor along the banks. The derived benefit from the recommend stabilization techniques depends upon which technique is used. Any restoration effort should include a monitoring plan to measure the success of the technique.

Water storage resulting in decreased discharge velocities may also be obtained through the construction of sediment basins along Crooked Creek. A 1997 letter from the Kosciusko County Soil and Water Conservation District recommends sediment basin installation along the creek (Appendix 11). Sediment basins also retain coarse sediment particles, preventing them from reaching the lake. While providing some benefits to the lake, sediment basins are not watershed restoration measures treating the cause of the sediment problem. Additionally, nutrients are often attached to finer silts and clays, particles that are not typically removed by sediment basins. Nonetheless, sediment basins would reduce some of the bank and stream bed erosion by controlling peak discharge velocities.

In addition to agricultural uses of the Crooked Creek subwatershed, the proposed Crooked Creek residential subdivision is of concern. The change in land use from a forested/open field mix to low or medium-density residential land has the potential to impact the adjacent creek in a number of ways. For example, increased nutrient loading rates to the creek will likely accompany the change in land use. The loading rates used as part of this study suggest an increase in phosphorus export to the creek from the change in land use. The U.S. Environmental Protection Agency's National Urban Runoff Program (EPA, 1983) results provide further evidence that pollutant runoff rates, including nutrients and suspended solids, will increase with such an alteration. If not limited or treated, these pollutants will ultimately reach Big Chapman Lake, potentially fertilizing algae and rooted plants and creating sediment deltas in the water.

The change in land use from forest/open field to low to medium-density residential will result in an increase in the amount of impervious surface. Zoning regulations often require retention of water on site such that there is no or little increase in peak flow from pre-development levels. Detention basins are typically engineered to do exactly this. While this helps prevent some erosion in the receiving creek, it does not address the increase in volume of water reaching the creek. The increased volume will result in increased bank and bed erosion in Crooked Creek. This is of particular concern since Crooked Creek already delivers the greatest amount of suspended solids to the lakes.

Management techniques are available to reduce some of the impacts the development will have on the creek and ultimately the lakes. The development should limit the amount of impervious surface. For example, roads should be as narrow as safety allows. Porous surfaces should be considered for driveways and other hard surfaces where feasible. Porous surfaces usually consist of a network of hard, impervious surfaces such as concrete or plastic interspersed with open areas where vegetation growth is possible. Grassed road shoulders should replace curb and gutter systems. Stormwater conduits should be disconnected where possible. Roof gutters should not channel water directly to storm drains. These practices take advantage of the natural infiltration capacity of the land, limiting the amount of water and any pollutants the water contains from reaching the detention basin.

Measures should be installed to treat the first flush of stormwater that does reach the detention basin. The first flush of stormwater often times contains the highest concentration of many pollutants. Good stormwater management involves treating this first flush off-line to prevent these pollutants from reaching the receiving waterbody. Because phosphorus and suspended solids are of most concern in Crooked Creek and ultimately Big and Little Chapman Lakes, the best management technique to use would be one that has high removal efficiencies for these two pollutants. Filtration trenches, sand filters, and wetlands are possible management techniques to treat the first flush.

Lozier's Drain Subwatershed

The Lozier's Drain subwatershed faces many of the same problems as the Crooked Creek subwatershed. Agricultural land use dominates the subwatershed. The Lozier's Drain subwatershed contains the greatest amount of highly erodible soil units of all the subwatersheds and nearly half of the subwatershed is mapped in potentially highly erodible soil units (Table 3 and Figure 25). Almost 140 acres (57 ha) of agricultural land in the watershed fits the Farm Service Agency's definition of Highly Erodible Land (Figure 26). The cumulative impact of these subwatershed characteristics was observed in the storm water sampling; Lozier's Drain ranked second to Crooked Creek in loading rates of most nutrients and sediment. The loading rate of nitrate-nitrogen and ortho-phosphorus exceeded Crooked Creek's loading rates of these parameters (Table 10).

Many of the same conservation methods described above for the Crooked Creek subwatershed may be utilized in the Lozier's Creek subwatershed. The establishment of buffer strips and grassed waterways, particularly in the headwaters of the subwatershed where most of the HEL exists, would help reduce any nutrient and sediment runoff. Nutrient and sediment runoff may also be reduced by setting aside land in the CRP or encouraging farmers that do not already do so to utilize conservation tillage methods. The possible benefits to Lozier's Creek and Little Chapman Lake from these management techniques were outlined above. The Lozier's Creek subwatershed may also benefit from the restoration of wetlands at the ditch's headwaters. Potential wetland restoration and/or enhancement sites include areas immediately north and south of County Road 200 North and west of County Road 400 East and an area centrally located in Section 1, south of County Road 200 North and west of County Road 400 East (Figure 49). The 1997 letter from the Kosciusko County Soil and Water Conservation District recommends installation of a stormwater retention basin immediately east of County Road 300 East (Appendix 11).

Arrowhead Park Drain and Highlands Park Drain Subwatersheds

Comparatively, these two drains deliver less pollutants to the lakes than Lozier's Creek and Crooked Creek. Evidence of sediment delivery exists, however, at the mouth of each of these drains in Little Chapman Lake. A sediment survey conducted in conjunction with this study (Appendix 12) documented the presence of approximately 1.4 acres (0.6 ha) of unconsolidated sediment at the mouth of Arrowhead Park Drain and approximately 0.33 acre (0.1 ha) of unconsolidated sediment at the mouth of Highlands Park Drain. The average depth of sediment at the mouth of Arrowhead Park Drain was approximately 1.5 feet (0.5 m). Less sediment deposition was observed at the mouth of the Highlands Park Drain where unconsolidated sediments averaged a depth of 3 feet (1 m).

An agricultural land owner in the upper portion of the Arrowhead Park subwatershed currently utilizes grassed waterways to help increase infiltration of runoff water, thereby reducing some of the volume and peak flows in the drain. Because a drain tile lies under the grassed waterway, complete infiltration is not possible. The grassed waterway does help reduce sediment transport by filtering sediment from the runoff. Bank stabilization techniques described for Crooked Creek would reduce sediment transport in the Arrowhead and Highlands Park drains as well. The 1997 letter from the Kosciusko County Soil and Water Conservation District proposes the construction of a stormwater sediment basin/wetland to reduce bank erosion in the Arrowhead Drain (Appendix 11).

Another issue of concern in the Arrowhead Park Drain is the elevated *E. coli* concentration at base flow conditions. The count of 8,300 col/100mL exceeds the state standard for a single sample and is a full order of magnitude over a typical average concentration for Indiana streams. (In a review of 50 streams in Indiana, White (unpublished data, 1991) determined the average *E. coli* concentration was approximately 645 col/100mL.) Wildlife, domestic pets and livestock, faulty septic systems, and manure fertilizers are the most likely sources of this *E. coli* contamination. Management techniques to prevent or reduce *E. coli* contamination include proper maintenance of existing septic systems, disposal of pet waste, manure management for livestock, installation of waste water wetlands in place of septic systems, and/or installation of a sanitary sewer system. Again the benefit derived from these management techniques depends on the techniques used.

Shoreline/Near Shore

The near shore area possesses the lowest percentage of highly erodible soils. It also has the second greatest percentage of wetlands remaining. Direct runoff from the land immediately adjacent to the lake was not measured as part of this study. Consequently, a determination of nutrient input from this area cannot be made. Land use immediately adjacent to the lakes does have an impact on lake water quality. Three areas of concerns were noted in the area immediately adjacent to the lake: residential lakeshore properties, roadside storm drains to the lake, and an area proposed for development.

Many of the shoreline residences on the lakes have maintained turf grass lawns. Fertilizers and pesticides from these lawns are a source of nutrients and toxins to the lakes. Lakeshore landowners should reduce or eliminate the use of lawn fertilizers and pesticides. Landowners typically apply more fertilizer to lawns and landscaped areas than necessary to achieve the desired results. Plants can only utilize a given amount of nutrients. Nutrients not absorbed by the plants or soil will run into the lake, providing a nutrient base for plants and algae in the lake. At the very minimum, landowners should follow dosing recommendations on product labels. Where possible, natural landscapes should be maintained to eliminate the need for pesticides and fertilizers. Alternatively, landowners should consider replacing high maintenance turf grasses with grasses that have lower maintenance requirements such as some fescue (*Festuca*) species.

In addition to reducing the amount of fertilizer used, landowners should apply phosphorus-free fertilizers. Most fertilizers contain both nitrogen and phosphorus. However, the soil usually contains enough natural phosphorus to allow for plant growth. As a consequence, fertilizers with only nitrogen work as well as those with both nutrients. The excess phosphorus that cannot be absorbed by the grass or plants runs off into the lake. Landowners can have their soil tested to ensure that their property does indeed have sufficient phosphorus and no additional phosphorus needs to be added. The local Soil and Water Conservation District or the NRCS can usually provide information on soil testing.

Landowners should also avoid depositing lawn waste such as leaves and grass clippings in the lake as this adds to the nutrient base in the lakes. While it is common for lake residents to dispose of goose droppings directly into the lake, any type of animal waste disposal into the Pet waste should be placed in residents' solid waste containers to be taken to the landfill rather than leaving the waste on the lawn to decompose. Any animal waste present along the shoreline will contribute nutrients and *E. coli* to the lakes during runoff storm events.

Lake residents should also consider replacing maintained lawns with native vegetation. In those areas that do not have seawalls, rushes (*Juncus* spp.), sedges (*Carex* spp.), pickerel weed (*Pontederia cordata*), arrowhead (*Sagittaria latifolia*) and blue-flag iris (*Iris viginica*) offer an aesthetically attractive, low profile community in wet areas. Behind existing seawalls, a variety of upland forbs and grasses that do not have the same fertilizer/pesticide maintenance requirements as turf grass may be planted in its place. Plantings can even occur in front of existing seawalls. Bulrushes (*Scirpus spp*.) and taller emergents are recommended for this. While not providing all the functions of a native shoreline, plantings in front of seawalls provide fish and invertebrate habitat. In addition, the restoration of native shoreline or the planting of emergents in front of seawalls also discourages Canada geese. The geese prefer maintained lawns because any predators are clearly visible in lawn areas. Native vegetation is higher in profile than maintained lawns and has the potential to hide predators, increasing the risk for the geese. Partial or full restoration of the native shoreline community with these measures would provide shoreline erosion control and filter runoff to the lakes, thus improving the lake's overall health without interfering with recreational uses of the lake.

Each lake owner should investigate local drains, roads, parking areas, driveways, and rooftops. The resident survey indicated that approximately 25% of the homes around the lakes have some sort of local drain on the property. These drains contribute to sediment and nutrient loading and thermal pollution to the lakes. Where possible, alternatives to piping the water directly to the lake should be considered. Alternatives include French drains (gravel filled trenches), wetland filters, catch basins, and native plant overland swales.

Septic systems around the lakes are also of concern. As indicated by the resident survey, some septic systems are treating larger waste streams than those for which they were originally designed due to home remodeling and greater residence times in the homes. Overloaded or leaking septic systems deliver nutrients and other pollutants such as *E. coli* to the lakes. This can increase the lakes' productivity and threaten human health. To address the problems posed by septic systems, properties owners should conduct regular septic tank maintenance. This means homeowners should have their tanks pumped once a year. For forgetful residents, many septic companies have programs in which the company automatically comes out once a year. Where necessary, systems should be upgraded to ensure they can handle any increases in waste stream that have occurred over the years (i.e. modernization of home, increases in residence time, etc.) Water conservation measures such as using low-flow toilets or taking shorter showers will also decrease loading to septic systems.

Those are the minimum steps that should be taken to prevent an increase in pollution from septic systems. Alternatives that actually reduce the waste stream should also be considered. For example, wastewater wetlands typically produce cleaner effluent at the end of a leach field than traditional systems. This is particularly true during the summer months, when plants in such a wetland operate at peak evapotranspiration capacity. Very little effluent leaves the wetlands. This reduction in effluent release corresponds with the peak times for potential algae blooms in the lake. The wetland is working hardest to prevent nutrients from reaching the lake at the exact time nuisance algae blooms could develop if sufficient nutrients are present. Leach fields of wastewater wetlands are smaller than traditional leach fields making them more attractive on lots where limited space is available. Finally, lake residents should give careful consideration to the installation of a sanitary sewer system around the lakes. While it may be expensive, a sewer system would eliminate a portion of the nutrient load reaching the lakes, improving their water quality and limiting their productivity (algae and rooted plant growth).

Storm water drains were identified as a potential problem in the near shore area. Figure 49 also maps several of the larger drains around the lakes. Additional smaller drains may also exist. Some of the storm drains are straight pipes to the lake. Traditional drop catch basins should be installed at a minimum on these storm drains to collect coarse sediments in the storm water. Drains may be retrofitted with a variety of filters that provide additional pollutant removal from storm water. Filters that maximize the removal of sediment and phosphorus are recommended. Traditional catch basins and many of these filters require regular maintenance to be effective.

Alternatively, storm water may be treated before it reaches the drain. Some roadside swales border the streets around the lakes. These swales filter pollutants before reaching the drain pipe. Vegetation should be maintained in these swales to maximize pollutant removal. Where space allows, installation of additional filtration systems such as sand filters should be considered to treat storm water before it enters the drains. Again, filtration systems with high sediment and phosphorus removal efficiencies should be utilized.

The final area of concern in the near-shore subwatershed is the proposed development of a property located north of Big Chapman Lake (Figure 49). Residential land development typically results in increased nutrient and sediment export from the land. Several techniques are available to treat urban storm water runoff. Many of these were outlined in the Crooked Creek subwatershed management section and will not be repeated here.

One technique not mentioned is the use of cluster housing plans and other conservation designs to reduce the amount of impervious surface of a residential development. Cluster housing developments have the same number of houses as non-cluster developments, but houses are clustered together in one section of the development creating more community open space. When properly planned (i.e. placement of the open space between the development and the lake to serve as a buffer), the result is an increase in storm water infiltration preventing pollutants and increased water volume from reaching the lake.

Chapman Lake residents should also consider working with local authorities to develop a zoning master plan for the watershed. Such a plan would establish guidelines for future development through zoning laws. It could require specific management techniques be employed to treat storm water or set specific limits on pollutant export from the site. The plan could also address housing density in the watershed. An erosion control ordinance should be included in such a master plan. Several communities in Indiana have successfully developed such plans to guide future development in their watershed and to ensure the protection the natural resources in their watershed. A concerted effort by Chapman Lake watershed stakeholders to work with local officials could result in a balanced master plan for the watershed.

IN-LAKE MANAGEMENT

Three areas of concern were identified in the Chapman Lakes themselves. Two, the boat use, or perhaps overuse, on the lakes and aquatic plants in the lakes were addressed in detail in the Resident Survey and Aquatic Plant Sections. Those discussions will not be repeated here. A third area of in-lake concern is internal phosphorus loading to the lakes. Results from the Vollenweider model (1975) suggest that approximately 22% of the total phosphorus load to Big Chapman Lake originates from internal sources. In Little Chapman Lake, internal loading accounts for approximately 37% of the total load. Two in-lake treatments are available to manage internal phosphorus loads: phosphorus inactivation and precipitation (alum treatments) and hypolimnetic aeration. Hypolimnetic aeration is less common, and success is typically less certain than alum treatments. Thus, aeration is not recommended for the Chapman Lakes.

Phosphorus precipitation and inactivation is designed to remove phosphorus from the water column <u>and</u> to prevent release of phosphorus from sediments. This nutrient control strategy is aimed at minimizing planktonic algal growth. The treatment involves adding aluminum salts to the lake. These salts form a floc or an agglomeration of small particles. This floc (e.g. $Al(OH)_3$) acts in two ways: (a) it absorbs phosphorus from the water column as it settles, and (b) it seals the bottom sediments if a thick enough layer has been deposited. Phosphorus can also precipitate out as an aluminum salt (e.g. $AlPO_4$).

Most phosphorus precipitation treatments employ liquid aluminum sulfate (alum) or sodium aluminate. The dosages are determined by a standard jar test, keeping in mind that aluminum solubility is lowest in the pH range 6.0 to 8.0. Cooke and Kennedy (1981) offer a detailed dose determination method. Aluminum toxicity does not appear to be a problem at treatment concentrations in well-buffered lakes as long as the pH remains above 6.0. Chemicals added for phosphorus control are applied either to the lake surface or to the hypolimnion, depending upon whether water column or sediment phosphorus control is most necessary.

The application procedure of aluminum salts to lake water has changed little since the first treatment in Horseshoe Lake, Wisconsin (Peterson et al. 1973). At Horseshoe Lake, alum slurry was pumped from a barge through a manifold pipe that trailed behind the vessel just below, and perpendicular to, the water surface. Today, new LORAN-guided high speed barges applying 4060 ft^3 (115 m^3) of liquid alum per day are the most advanced application vessels available (Cooke et al., 1993).

The season of application is critical for phosphorus removal, since different forms of phosphorus predominate in the water column on a seasonal basis. Phosphorus removal is most effective in early spring or late fall when most phosphorus is in an inorganic form that can be removed almost entirely by the floc.

Phosphorus precipitation and inactivation is most effective in lakes with long hydraulic residence times and low watershed phosphorus loading (Olem and Flock, 1990). In lakes with short residence times, new water from the watershed is continually replacing the water in a lake basin. If this water contains a high phosphorus load, the new phosphorus immediately replaces the phosphorus that was precipitated out of the water column. This new phosphorus also promotes the growth of algae and rooted plants. When these organisms die and sink to the lake's sediment, they form a new sediment layer over the alum treatment's seal. The seal is not able to prevent the release of phosphorus from the dead organisms that have settled onto the top of it.

Regardless of the lake hydraulic residence time, decomposition of aquatic organisms and sedimentation will naturally occur within a lake. This limits the alum treatment's effectiveness to approximately five to ten years (Olem and Flock, 1990). In some lakes, the phosphorus inactivation has been effective for as long as twelve years. The treatment's expected length of effectiveness should always be weighed against its cost. Costs vary depending upon the location and size of lake, type of applicator barge utilized for treatment, and other factors. Cooke et al. (1993) reports a cost of approximately $1,600 per acre ($640/ha) using a newer (faster) barge applicator.

An alum treatment should always be performed by an experienced applicator. An experienced applicator will test chemical conditions in the lake to ensure parameters are within ranges necessary to attempt a treatment (i.e. sufficient buffering capacity and water hardness). In addition, an experienced applicator will monitor the lake during treatment to ensure that the pH of the lake does not fall below 5.5-6.0. Below this pH range, conditions are appropriate for the formation of Al^{3+}, which is toxic to many organisms.

Cooke et al. (1993) outlines several of the potential drawbacks to alum treatments. These include the potential for increased rooted plant growth. As phosphorus that was once available for algae growth is removed from the water column, algae growth is reduced. This may increase water transparency. Increased water clarity allows for greater light penetration which could enhance rooted plant growth. Food chain impacts from the immediate reduction of algae could also affect a lake's fishery. Finally, the toxicity of aluminum even in neutral or basic conditions (pH >7) is of some concern to researchers.

RECOMMENDATIONS

The preceding management discussion provides a wish list of possible management options available to improve the health of the Chapman Lakes and their watershed. Financial, time manpower, and other restraints make it impossible to implement all of these management techniques all at once. Thus, it is necessary to prioritize the recommendations.

In comparison to many other area lakes, Big Chapman Lake possesses relatively good water quality. This water quality provides lake residents with an outstanding natural resource capable of supporting a wide variety of uses. Excellent water quality also increases property values around the lake. Because it is usually less costly to maintain lake water quality than it is to restore it once it becomes degraded and because it often takes a long period of time to restore a degraded lake, efforts to maintain the water quality of Big Chapman Lake should receive the highest priority in any watershed management plan. Specifically, management efforts should focus on the Crooked Creek subwatershed where elevated loads of sediment were identified. Management efforts applied to Big Chapman Lake will also improve Little Chapman Lake since its water discharges to Little Chapman Lake.

Secondary priority should be given to treating watershed issues in the subwatersheds that discharge directly to Little Chapman. Specifically, management efforts should focus on the Lozier's Creek and Arrowhead Drain subwatersheds where high pollutant loadings were identified. Management techniques would include watershed BMPs, wetland restoration, and bank and channel stabilization. Efforts to control loading should occur before any dredging of the lakes occurs. If the watershed is not managed first, dredging will need to be repeated and thus would not be very cost effective or permissible by the regulatory agencies.

Little Chapman Lake suffers from poorer water quality than Big Chapman Lake. Fortunately, successful restoration of Little Chapman Lake's water quality may be achieved more quickly given its relatively shorter hydraulic residence time. A short residence time means the lake is regularly flushed with runoff from the watershed. When this watershed runoff contains a high concentration of pollutants, the lake receives regular inputs of these pollutants. If improvements are made in the watershed to reduce pollutant loads, the lake with a shorter residence time will have a speedier recovery than a lake with a longer residence time since it is continually flushed with clean water.

In-lake treatments to manage internal phosphorus loading, such as an alum treatment, should receive a lower priority than watershed treatments for both lakes. In-lake treatments are often more effective once external phosphorus loading has been controlled. In addition, the relatively short residence time of Little Chapman Lake suggests an alum treatment will be less effective in that lake. Thus, management efforts should focus on the watershed before allocating funds to in-lake treatments.

Based on this rationale, below is a prioritized list of management recommendations. This is simply a guideline based on the current ecological condition of the lakes and their watershed.

These conditions may change as land and lake uses change. Individual lake residents may wish to prioritize the management effort differently to accommodate their specific desired uses of the lake. To ensure maximum participation in the any management effort, all watershed stakeholders should be allowed to participate in prioritizing the management efforts in the watershed.

It is also important to note that even if all stakeholders agree this is the best prioritization to meet their needs, action need not be taken in this order. Some of the smaller, less expensive recommendations, such as the homeowner recommendations, may be implemented while funds are raised to implement some of the larger projects. Many of larger projects will require feasibility studies to ensure landowner willingness to participate in the project and regulatory approval of the project. This regulatory approval along with resident input may ultimately determine the prioritization of management efforts.

1. Implement bank and channel erosion control techniques along the lower portions of Crooked Creek to stabilize the channel and reduce sediment and nutrient loading to Big Chapman Lake.

2. Work with the Soil and Water Conservation District (SWCD) office, the surveyor's office, and landowners to install BMPs or restore wetlands in the Crooked Creek subwatershed. (See Figure 49 for specific locations.) Work with SWCD and landowners to place agricultural land in CRP where possible or utilize conservation tillage methods.

3. Work with the developer of the proposed Crooked Creek development to ensure the best possible storm water filtration and volume reduction techniques are being utilized. Also explore with the developer the options available to limit the amount of impervious surfaces in the proposed development.

4. Work with the SWCD office, the surveyor's office, and landowners to install BMPs or restore wetlands in the Lozier's Creek subwatershed. (See Figure 49 for specific locations.) Work with the SWCD and landowners to place agricultural land in CRP where possible or utilize conservation tillage methods.

5. Implement bank and channels erosion control techniques along Arrowhead Park Drain to stabilize the channel and reduce sediment and nutrient loading to Little Chapman Lake.

6. Home Owner Recommendations:

   a) use only phosphorus-free fertilizers.
   b) consider natural stone or aquatic vegetation to protect shoreline from erosion instead of concrete seawalls; consider planting native vegetation in front of existing seawalls.

c) examine all drains that lead from roads, driveways or rooftops to the lake; consider alternate routes for these drains that would filter pollutants before they reach the lake.
d) keep organic debris such as lawn clippings, leaves, or animal waste out of the water.
e) use idle speeds in shallow water to limit prop wash and mark those areas with buoys.

7. Consider installing a sanitary sewer system around the lakes. At a minimum, maintain existing septic systems and upgrade any systems as needed. Consider using wastewater wetlands in lieu of septic systems as these provide greater treatment of effluent than traditional septic systems.

8. Develop a recreational use management plan to address current use conflicts and balance these conflicts in a fair democratic manner. The plan should reflect an understanding of how certain uses affect the lakes' water quality as well. To be effective, all lake users must be included in the plan's development.

9. Work with local authorities to develop a zoning Master Plan for the watershed.

10. Fit direct storm water drain pipes with catch basins at a minimum. Consider installing storm water filters to trap sediment and remove pollutants from runoff. Explore the possibility of constructing biofilters or filtration systems to treat residential or roadside runoff.

11. Develop an aquatic plant management plan that comprehensively addresses control of invasive species, the issue of phosphorus created by decomposing plants, and the importance of preserving and promoting native plants for water quality, fish, and aquatic invertebrate habitat. Any aquatic plant management plan must recognize and adjust to the two very different community types in each lake.

12. Controlling external phosphorus loading may be sufficient to control phosphorus concentration in the lakes. Once phosphorus loading from the watershed has been controlled, consider sampling the lakes again to determine if any in-lake treatments, such as alum treatments, are necessary.

13. Once external sediment loading is controlled, consider dredging selected areas (mouth of the Arrowhead Park Drain, mouth of Crooked Creek, etc.) to improve recreational use of the lakes.

LITERATURE CITED

Adams, R.W. 1983. Guidelines for use of the herbicide 2, 4-D to control Eurasian Water Milfoil in British Columbia. Lake Restoration, Protection and Management Proceedings of the Second Annual Conference of the North American Lake Management Society. EPA 440/5-83-00. U.S. Environmental Protection Agency, Washington, D.C.

Asplund, T.R. 1996. Impacts of Motor Boats on Water Quality in Wisconsin Lakes. Final Report to the Bureau of Water Resources Management Lake Management Section. Wisconsin Department of Natural Resources, Bureau of Research, Monona, Wisconsin.

Beard, T.D. 1973. Over winter drawdown; Impact on the aquatic vegetation in Murphy Flowage, Wisconsin. Tech. Bull. No. 61. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Blatchley, W.S. 1900. Indiana Department of Geology and Natural Resources – Twenty-Fifth Annual Report. Wm. B. Burford Printing, Indianapolis, IN.

Borman, S., R. Korth, and J. Temte. 1997. Through the Looking Glass: A Field Guide to Aquatic Plants. Reindl Printing, Inc., Merrill, Wisconsin.

Born, S.M., T.L. Wirth, E.M. Brick, and J.P. Peterson. 1973. Restoring the recreational potential of small impoundments. Tech. Bull. No. 70. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography, 22(2):361-369.

Chow, U.T. (Ed.). 1964. Handbook of Applied Hydrology. McGraw-Hill Book Company, New York.

CLP. 1989. Indiana Clean Lakes Program files. School of Public and Environmental Affairs, Indiana University, Bloomington, IN

CLP. 1993. Indiana Clean Lakes Program files. School of Public and Environmental Affairs, Indiana University, Bloomington, IN.

CLP. 1994. Indiana Clean Lakes Program files. School of Public and Environmental Affairs, Indiana University, Bloomington, IN.

CLP. 1996. Indiana Clean Lakes Program files. School of Public and Environmental Affairs, Indiana University, Bloomington, IN

CLP. 1998. Indiana Clean Lakes Program files. School of Public and Environmental Affairs, Indiana University, Bloomington, IN.

CLP. 1999. Indiana Clean Lakes Program data files – 1991, 1994, 1998. School of Public and Environmental Affairs, Indiana University, Bloomington.

CLP. 2000. Indiana Clean Lakes Program files. School of Public and Environmental Affairs, Indiana University, Bloomington, IN

Conservation Technology Information Center. Conservation Buffer Facts. [web page] No date. http://www.ctic.purdue.edu/core4/buffer/bufferfact.html. [Accessed March 3, 2000]

Cooke, G.D. 1980. Lake level drawdown as a macrophyte control technique. Water Resources Bulletin, 16:317-322.

Cooke, G.D., and R.H. Kennedy. 1981. Precipitation and Inactivation of Phosphorus as a Lake Restoration Technique. EPA-600/3-81-012.

Cooke, G.D., and R.H. Kennedy. 1989. Water Quality Management for Reservoirs and Tailwaters. Report 1. In-lake Reservoir Water Quality Management Techniques. Tech. Rep. E-89-1. U.S. Army Corps of Engineers. Vicksburg, Mississippi.

Cooke, G.D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. Restoration and management of lakes and reservoirs. Second edition. Lewis Publishers, Boca Raton, Florida.

Cornell Cooperative Extension. 1996. Video- "Restoring the Balance: Biological Control of Purple Loosestrife". Cornell University Media Services, Ithica, New York.

Fox, J.L., P.L. Brezonick, and M.A. Keirn. 1977. Lake drawdown as a method of improving water quality. EPA-600/3-77-005.

Grant, W. 1999. A survey for septic system effects on Barbee Lake Chain, Indiana.

Hanson, M.J., and H.G. Stefan. 1984. Side Effects of 58 Years of Copper Sulfate Treatment of the Fairmont Lakes, Minnesota.

Hippensteel, P. 1989. Preliminary Investigation of the Lakes of Kosciusko County. Tri-State University, Angola, Indiana.

Homoya, M.A., B.D. Abrell, J.R. Aldrich, and T.W. Post. 1985. The natural regions of Indiana. Indiana Academy of Science. Vol. 94. Indiana Natural Heritage Program. Indiana Department of Natural Resources, Indianapolis, Indiana

Hudak, D.C. 1995. Letter to R.G. Fuller, U.S. Army Corps of Engineers. In: Upper Tippecanoe River Basin Kosciusko County, Indiana. Interim Reconnaissance Report, U.S. Army Corps of Engineers, Louisville District, Volume 2, Appendix C.

Hudson, G. 1969. Fish Management Report, Little Chapman Lake, Kosciusko County. Indiana Department of Natural Resources. Indianapolis, Indiana.

Indiana Department of Environmental Management. Clean Lakes Program. 1990, 1994, 1998.

IDEM. 1986. Indiana Lake Classification System and Management Plan. Department of Environmental Management, Indianapolis, Indiana.

IDEM. 2000. Indiana Water Quality Report. Department of Environmental Management, Indianapolis, Indiana.

IDNR. 1996. Indiana Wetlands Conservation Plan. Indianapolis, Indiana.

Jones, W. 1996. Indiana Lake Water Quality Update for 1989-1993. Indiana Department of Environmental Management. Clean Lakes Program. Indianapolis, Indiana.

Landers, D.H. and D.G. Frey. 1980. The Die-Back Role of Myriophyllum spicatum in Monroe Reservoir. Technical Report No. 134. Purdue University Water Resources Research Center, West Lafayette, IN.

McComas, S. 1993. Lake Smarts. The Terrene Institute, Washington, D. C. 215 pp.

McGinty, D.J. 1964. Lake Survey Report Big Chapman Lake, Kosciusko County, Indiana. Indiana Department of Natural Resources. Indianapolis, Indiana.

National Climatic Data Center. 1976. Climatography of the United States. No.60.

Olem, H. and G. Flock, eds. 1990. Lake and reservoir restoration guidance manual. 2nd edition. EPA 440/4-90-006. Prepared by North American Lake Management Society for U.S. Environmental Protection Agency, Washington, DC.

Pearson, J. 1980. Preliminary investigations of the Chapman Lake Walleye Population. Indiana Department of Natural Resources. Indianapolis, Indiana.

Pearson, J. 1981. Fishing Pressure and Harvest at Big Chapman Lake. Indiana Department of Natural Resources. Indianapolis, Indiana.

Pearson, J. 1991. Big Chapman Lake, Kosciusko County, Fish Population Survey. Indiana Department of Natural Resources. Indianapolis, IN.

Pearson, J. 1999. Big Chapman Lake, Kosciusko County, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana.

Pearson, J. 1999. Little Chapman Lake, Kosciusko County, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana.

Peterson, J.O., J.T. Wall, T.L. Wirth, and S.M. Born. 1973. Eutrophication Control: Nutrient Inactivation by Chemical Precipitation at Horseshoe Lake, WI. Tech. Bull. 62. Wisconsin Department of Natural Resources, Madison, Wisconsin.

Prescott, G.W. 1982. Algae of the Western Great Lakes Area. Otto Koeltz Science Publishers, West Germany.

Prodan, W.T. 1983. Milfoil control in Seattle and the King County Region: Metro's Harvesting Program. Cited in Lake Restoration, Protection and Management. Proceedings of the Second Annual Conference of the North American Lake Management Society. EPA 440/5-83-00. U.S. Environmental Protection Agency, Washington, D.C.

Pullman, G.D. 1992. Aquatic Vegetation Management Guidance Manual, Version 1. The Midwest Aquatic Plant Management Society, Flint, Michigan.

Purdue Applied Meteorology Group. Department of Agronomy. Indiana Climate Page. [web page] No date. http://shadow.agry.purdue.edu/sc.index.html [Accessed February 13, 2001]

Reckhow, K.H., M.N. Beaulac, and J. T. Simpson. 1980. Modeling phosphorus loading and lake response under uncertainty: A manual and compilation of export coefficients. EPA 440/5-80-11. U.S. Environmental Protection Agency, Washington, D. C.

Reckhow, K.H. and J.T. Simpson. 1980. A procedure using modeling and error analysis for the prediction of lake phosphorus concentration from land use information. Can. J. Fish. Aquat. Sci., 37:1439-1448.

Ricker, W.E. 1942. The rate of growth of bluegill sunfish in lakes of northern Indiana. Investigations of Indiana Lakes and Streams, 2:161-214.

Shipman, S.T. 1976. Big Chapman Lake, Kosciusko County, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana.

Shipman, S.T. 1976. Little Chapman Lake, Kosciusko County, Fish Management Report. Indiana Department of Natural Resources. Indianapolis, Indiana.

Shipman, S.T. 1989. Largemouth Bass Population Size and Exploitation Rate at Two Natural Lakes. Indiana Department of Natural Resources. Indianapolis, Indiana.

Smith, C.S. and J.W. Barko. 1990. Ecology of Eurasian watermilfoil. J. Aquat. Plant Manage. 28: 55-64.

Staley, L.R. 1989. Soil Survey of Kosciusko County, Indiana. United States Department of Agriculture, Indianapolis, Indiana.

Stewart, J.A., C.R. Keeton, L.E. Hammil, H.T. Nguyen and D.K. Majors. 1999. Water Resources Data - Indiana Water Year 1998. Data Report IN-98-1. U.S. Geological Survey, Indianapolis, IN.

U.S. Environmental Protection Agency. 1977. Report to Congress – Waste Disposal Practices and Their Effects on Ground Water, US Environmental Protection Agency, Washington, D.C. Cited in Grant, W. 1999. A survey for septic system effects on Barbee Lake Chain, Indiana.

U.S. Environmental Protection Agency. 1983. Report on Webster Lake, Kosciusko County, Indiana, Indiana. EPA Region V Working Paper No. 345.

U.S. Environmental Protection Agency. 1983. Results of the Nationwide Urban Runoff Program, Volume I: Final Report. Water Planning Division, NTIS PB#84-185554.

U.S. Census of Agriculture. 1999 Census of Agriculture Facts. [web page] No date. http://www.aes.purdue.edu/agstat/annbul/9899. [Accessed March 9, 2000]

Vollenweider, R.A. 1975. Input-output models with special reference to the phosphorus loading concept in limnology. Schweiz Z. Hydrol, 37(1):53-84.

Wagner, K.J. 1991. Assessing the impacts of motorized watercraft on lakes: issues and perceptions. In: Proceedings of a National Conference on Enhancing States' Lake Management programs, May 1990. Northeastern Illinois Planning Commission, Chicago, IL. p. 77-93.

Ward, H.B. and G.C. Whipple. 1959. Freshwater Biology, Second Edition. W.T. Edmondson, editor. John Wiley & Sons, Inc., New York.

Westerdahl, H.E., and K.D. Getsinger. 1988. Efficacy of Sediment-applied Herbicides Following Drawdown in Lake Ocklawaha, Florida. Information Exchange Bulletin, A-88-1. U.S. Army Corps of Engineers, Vicksburg, Mississippi.

White, G.M. 1998a. Exotic plant species in Indiana Lakes. Report prepared for the Nonindigenous Aquatic Species Database, USGS, Gainesville, Florida. Indiana Department of Natural Resources, Division of Soil Conservation.

White, G.M. 1998b. Factors affecting and estimated cost of aquatic plant control in Indiana Lakes. Indiana Department of Natural Resources, Division of Soil Conservation.

Whitford, L.A. and G.J. Schumacher. 1984. A Manual of Fresh-Water Algae. Sparks Press, Raleigh, N.C.

Yousef, Y.A., W.M. McLellon, R.H. Fagan, H.H. Zebuth, and C.R. Larrabee. 1978. Mixing effects due to boating activities in shallow lakes. Draft Rep. To OWRT, U.S. Dep. Inter. Tech. Rep. ESEI No. 78-10, Washington, D.C. 199 pp.

APPENDICES

APPENDIX 1:

Chapman Lake Conservation Club
Lake Resident Survey
and Survey Instructions

TASK FORCE SURVEY TEAM INSTRUCTIONS

Each team must follow these instructions carefully. It is important to check off all applicable answers. Take special care to NOT influence answers with your own views or the views of others. It is vital this survey accurately represents the confidential views of the Chapman Lakes area resident you are interviewing.

Each team will be assigned a Team Number and a specific area to survey. EVERY residence, or business, of whatever kind or character is to be surveyed and marked on your Lake Zone Map. The functions of this survey are three-fold: 1) To specifically identify, locate and count every dwelling around the Chapman Lakes and watershed; 2) Determine property types and uses; 3) Determine resident uses of the lakes, and, their views on specific issues. Information will be codified and be of tremendous value during the LARE lake and watershed diagnostic study CLCC is undertaking, and, for any future planning for lake enhancement and preservation. Organize and plan your area before starting out. Try to stay with a door-to-door plan rather than hit or miss. Remember it is vital EVERY place be surveyed. An organized plan or approach will help avoid missed properties. BE SURE TO CAREFULLY INTRODUCE YOUR TEAM TO THE RESIDENT YOU ARE APPROACHING. WEAR YOUR IDENTIFICATION! Individual survey information will NOT be made public in order to protect the privacy of residents and property owners. This is a PERSONAL INTERVIEW SURVEY. Do NOT leave the form with the resident. It is the responsibility of the Survey Team to assure the form is marked as the resident is being interviewed. Allow 15-30 minutes.

1 Fill in the identification box in the upper right hand corner. Insert your TEAM NUMBER. Insert the LAKE ZONE you are surveying. Insert the PROPERTY NUMBER you have given to this property. Be sure the property number on the survey corresponds with the number you enter on your Lake Zone Map. It is very critical that property locations and zones be carefully numbered in order that resulting survey information be usable **even if the resident refuses to participate**.

2 **Property Location and Address.** Insert here the street or roadway address of the property. Use the actual house number and posted road sign name, such as "24 C22E-3", or "1234 W 300 N". It is not necessary to use "EMS" or "Lane". While the resident's name is not required, this information can be useful later if the individual does not object. **DO NOT LEAVE THE SURVEY FORM WITH THE RESIDENT.**

3 **CHECK BOXES.** Most responses require only a simple check mark. In order to avoid confusion, the check boxes [ ] shown on the form are all in front of the answer being checked. No check boxes follow an answer. So, if you check a box following an answer, that box is for the next answer. Some answers require the appropriate answer to be circled. In the "About Your Area" section the resident is asked to estimate how many times in how many years something has occurred. Use the resident's best guess. This is a multiple choice, simple form, if residents want to elaborate, just write their comments in the "Here's Your Chance" section of the survey, or, write on the reverse side.

4 There are six specific areas on the questionnaire to be completed. Each should be finished before moving on to another section. That way nothing will be missed.

5 **"About You & Your Lake Use".** This section concerns the resident and how they use the lake. First, we want to know how long they have lived (or rented) here. Then, we ask the kinds of vessels they commonly use on the lake, how they recreate on the lake. While year-around residents may also use the lake in winter, these questions generally pertain only to the warm months of the year. You will note we want to know generally about how often they or members of their family and guests are on the lake in season, and, on which lake most time is spent. People "day camp" on the lake by parking in shallow areas. We want to know about how often they do that during the season.

6 **"About the Property".** This is an important section to learn what a property contributes to the lake. First, we need to know what kind of dwelling and the approximate age (how long ago was the original building built), and when last remodeled. Remodeling means "major" changes, not just a porch or deck. The balance of the questions tell us about the property and its facilities. Take special precautions to carefully check the correct responses here.

7 **"Your Property General Lake Location".** In the first part of this section, you will actually mark two boxes, one for which lake, and, one for whether lake frontage or channel. Location to be circled means generally in what general direction of the lake shoreline this property is located, such as "north side" "south side", etc. Some locations have a commonly used location name, like Chapman Lake Park, Island Park. Nellie's Bay, etc. Write that down.

8 **"About Your Area".** People who live there can tell us most about what occurs at their location. This section is especially important to the LARE diagnostic study. This section can identify potential or past watershed problem areas, sediment build-up areas, and, excessive weed growth. Time frames given here will be valuable in making other determinations about lake turn-over. It is not necessary to have exact dates, just best to their knowledge.

9 **"Your Perceptions of the Lakes".** It is not necessary to be a biologist, just mark the general perception. Be careful to notice that the time frame does NOT have to be the same in both "better" and "worse" categories. In fact, it tells more if these are different because it can indicate a specific time when things changed. Remember, these are "perceptions", not scientific measurements.

10 **"Here's Your Chance".** This section is important to the resident. Spout off what they think without threat of reprisal. Additionally, CLCC gets a chance to find out if the resident is a member, and/or supports our organization and it's efforts. We can even find out why they are not participating and that will help us make changes for the better. This is also an opportunity to encourage members. For proper accounting, however, contributions should be mailed to: **CLCC, P. O. Box 776, Warsaw, IN 46581-0776**. But... if someone wants to write a check to CLCC and give it to you, **TAKE IT!**

If the interview is refused, write 'REFUSED" across the survey, but be sure to identify the property.
FINALLY: Date and initial the completed survey.

CL Chapman Lakes Conservation Club, Inc ™

Date Completed: ________	DO NOT WRITE IN BOX	Team #	Lake Zone
Team Initial: ________		Property #	

CONFIDENTIAL CHAPMAN LAKES AREA PROPERTY AND RESIDENT SURVEY

NOTICE: The purpose of this survey is to identify properties and uses surrounding Chapman Lake, and, to determine directly from Chapman Lakes area residents their thoughts on the quality of life at the lakes including perceived problems, difficulties, likes and dislikes. This survey is in connection with the lakes and watershed diagnostic study and lake enhancement projects being voluntarily undertaken by the Chapman Lakes Conservation Club, Inc., in the public interest. YOU ARE UNDER NO OBLIGATION TO COMPLETE THIS SURVEY. While your address is necessary, your name is not. CLCC members will be wearing Chapman Lakes Conservation Club, Inc., identification.

PROPERTY LOCATION ADDRESS: ____________________

OWNER'S NAME: (Optional) ____________________
If owner's permanent address is different than above, please list: ____________________
____

ABOUT YOU & YOUR LAKE USE:
Are you: [ ] Owner [ ] Tenant [ ] Corporate owner
How many years have you occupied\owned this property
[ ] 1+ [ ] 3+ [ ] 5+ [ ] 10+ [ ] 15+ [ ] More than 20

What kinds of watercraft do you own:
[ ] Row boat [ ] Ski boat [ ] Personal watercraft [ ] Sailboat
[ ] Canoe [ ] Paddle boat [ ] Bass boat [ ] Outboard fishing boat [ ] Pontoon/Deck boat [ ] Other ________

Do you: [ ] Fish [ ] Power boat [ ] Personal watercraft
[ ] Swim in lake [ ] Water ski [ ] Sail [ ] SCUBA

In season, how often are you ON the lakes:
[ ] Daily [ ] 1-2 Weekly [ ] 3-4 Weekly [ ] 4-6 Weekly
[ ] Constantly [ ] Weekends only [ ] Weekdays only
We spend most time on the [ ] Big lake [ ] Little lake
[ ] Fishing areas
Do you "park" and picnic on the lake? [ ] Yes [ ] No
[ ] Often [ ] Weekends [ ] Seldom [ ] Never

ABOUT THE PROPERTY:
[ ] Home [ ] Cottage [ ] Mobile Home [ ] Commercial
[ ] Single Family [ ] Multiple [ ] Other ________
Age of dwelling: [ ] 1+ [ ] 5+ [ ] 10+ [ ] 20+ [ ] Older
Last remodeled: [ ] 1+ [ ] 5+ [ ] 10+ [ ] 15+ [ ] 20+
Shoreline is: [ ] Seawall [ ] Rock [ ] Natural [ ] Channel
No. Bedrooms ____ No. Baths ____ Well Size: **2 3 4 6**
Washer/dryer? [ ] Yes [ ] No Garb. disposer? [ ] Yes [ ] No
Circle septic system age: **1+ 5+ 10+ 15+** Mound? **Y N**
Occupied when: [ ] Year around [ ] Summer [ ] Weekends
[ ] Other: ________
If not on lake or channel, does the property have deeded access to lake? [ ] Yes [ ] No
Do you direct or pipe any type of water into lake? [ ] Rain gutters [ ] Washers [ ] Garage drain [ ] Other ________
Do you irrigate your lawn from the lake?: [ ] Yes [ ] No
YOUR PROPERTY GENERAL LAKE LOCATION:
[ ] Big Chapman [ ] Little Chapman [ ] Frontage [ ] Channel
[ ] Neither. Circle location: **N NE E SE S SW W NW**
Common name of location area (if any): ________.

ABOUT YOUR AREA: Identify what has occurred AT your property as listed and described above.
[ ] Lake high water over the shore/seawall, estimated ___ times in past ___ years. [ ] Storm water runoff onto your property estimated ___ times in past ___ years. [ ] Ditch overflow onto your property estimated ___ times in past ___ years.
[ ] Sediment build-up in lake at your location has occurred in estimated past ___ years. [ ] Lake weed build-up at your location over past ___ years. [ ] Yes, we travel a channel to get to either lake [ ] Our property would best be described as on a hill
[ ] Our property would best be described as low near the lake level. [ ] No change or nothing observed.

YOUR PERCEPTIONS OF THE LAKES: General lake use has [ ] Increased [ ] No change [ ] Decreased
Water clarity is: [ ] Better than last (circle one) 1 5 10 15 20 years. [ ] Worse than last (circle one) 1 5 10 15 20 years.
Fishing is: [ ] Better than (circle one) 1 5 10 15 20 years [ ] Worse than last (circle one) 1 5 10 15 20 years.
Lake's biggest problem is: [ ] Boat population [ ] Weeds [ ] Storm run-off [ ] Zebra mussels [ ] Other (specify): _____
____________________.

HERE'S YOUR CHANCE (Please be specific):
What bothers you most at the lake: ____________________

What do you like most at the lake: ____________________

Are you a CLCC member? [ ] Yes [ ] No If not, why not. ____________________

Do you contribute to CLCC sponsored [ ] Independence Day [ ] Lake Enhancement Fund

This form will be provided and collected only by a CLCC member.

APPENDIX 2:

Detailed Land Use for the Chapman Lakes

Detailed Land Use for the Chapman Lakes Subwatersheds

Land use	Subwatershed 1 (acres)	1 (hectares)	Percent	2 (acres)	2 (hectares)	Percent	3 (acres)	3 (hectares)	Percent
Ag. Pasture/Grassland	15.6	6.31578947	0.018598	0	0	0	4	1.619433198	0.013201
Ag. Row Crop	732.1	296.396761	0.872794	88.2	35.708502	0.724733	263.6	106.7206478	0.869967
Urban Low Density	0.1	0.04048583	0.000119	13.4	5.42510121	0.110107	2.5	1.012145749	0.008251
Palustrine Forested Deciduous	23.4	9.47368421	0.027897	0	0	0	10.7	4.331983806	0.035314
Palustrine Shrubland Deciduous	10.3	4.17004049	0.012279	0	0	0	0	0	0
Palustrine Herbaceous Deciduous	0	0	0	0	0	0	0	0	0
Palustrine Sparsely Vegetated	0	0	0	0	0	0	0.2	0.08097166	0.00066
Palustrine Woodland Deciduous	0	0	0	0	0	0	0	0	0
Terrestrial Shrubland Deciduous	3.8	1.53846154	0.00453	0	0	0	0	0	0
Terrestrial Forest Deciduous	52.6	21.2955466	0.062709	20.1	8.13765182	0.16516	22	8.906882591	0.072607
Terrestrial Woodland Deciduous	0.9	0.36437247	0.001073	0	0	0	0	0	0
Terrestrial Forest Evergreen	0	0	0	0	0	0	0	0	0
Terrestrial Forest Mixed	0	0	0	0	0	0	0	0	0
Water	0	0	0	0	0	0	0	0	0
Totals	**838.8**	**339.595142**	**1**	**121.7**	**49.2712551**	**1**	**303**	**122.6720648**	**1**

Subwatershed	
1	Lozier's Creek Subwatershed
2	Highlands Park Drainage Subwatershed
3	Arrowhead Park Drainage Subwatershed
4	Crooked Creek Subwatershed
5	Area draining to lake directly or via smaller inlets

Detailed Land Use for the Chapman Lakes Subwatersheds

Land use	4 (acres)	4 (hectares)	Percent	5 (acres)	5 (hectares)	Percent	Total (acres)	Total (hectares)	Percent
Ag. Pasture/Grassland	12.1	4.89878543	0.015603	108.3	43.8461538	0.043017	140	56.68016194	0.030725
Ag. Row Crop	645.2	261.214575	0.831979	976	395.1417	0.387671	2705.1	1095.182186	0.593666
Urban Low Density	1.7	0.68825911	0.002192	204.1	82.6315789	0.081069	221.8	89.79757085	0.048677
Palustrine Forested Deciduous	20.8	8.42105263	0.026821	33.3	13.4817814	0.013227	88.2	35.70850202	0.019357
Palustrine Shrubland Deciduous	6.7	2.71255061	0.00864	265	107.287449	0.105259	282	114.1700405	0.061888
Palustrine Herbaceous Deciduous	0	0	0	75.3	30.48583	0.029909	75.3	30.48582996	0.016525
Palustrine Sparsely Vegetated	0	0	0	74.4	30.1214575	0.029552	74.6	30.20242915	0.016372
Palustrine Woodland Deciduous	2.9	1.17408907	0.00374	0	0	0	2.9	1.174089069	0.000636
Terrestrial Shrubland Deciduous	0	0	0	6.2	2.51012146	0.002463	10	4.048582996	0.002195
Terrestrial Forest Deciduous	86.1	34.8582996	0.111025	155.1	62.7935223	0.061606	335.9	135.9919028	0.073717
Terrestrial Woodland Deciduous	0	0	0	6.7	2.71255061	0.002661	7.6	3.076923077	0.001668
Terrestrial Forest Evergreen	0	0	0	9.3	3.76518219	0.003694	9.3	3.765182186	0.002041
Terrestrial Forest Mixed	0	0	0	5.5	2.22672065	0.002185	5.5	2.226720648	0.001207
Water	0	0	0	598.4	242.267206	0.237687	598.4	242.2672065	0.131326
Totals	**775.5**	**313.967611**	**1**	**2517.6**	**1019.27126**	**1**	**4556.6**	**1844.777328**	**1**

APPENDIX 3:

Endangered, Threatened, and Rare
Species List,
Chapman Lakes Watershed

ENDANGERED, THREATENED, AND RARE SPECIES
AND HIGH QUALITY NATURAL COMMUNITIES AND NATURAL AREAS DOCUMENTED FROM
THE CHAPMAN LAKE WATERSHED, KOSCIUSKO COUNTY, INDIANA

Type.........	Element Name................	Common Name..............	State	Fed..	Townrang	Sec...............		Date	Comments
LEESBURG QUADRANGLE									
Plant	ELEOCHARIS GENICULATA	CAPITATE SPIKE-RUSH	ST	**	033N006E	25		1941	
Plant	UTRICULARIA RESUPINATA	NORTHEASTERN BLADDERWORT	SX	**	033N006E	25		1941	
Reptile	SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA	SE	C	033N006E	35	NWQ	1988	
BIG CHAPMAN LAKE NATURE PRESERVE	(DNR NATURE PRESERVES)								
Bird	CIRCUS CYANEUS	NORTHERN HARRIER	SE	**	033N006E	26	SWQ	1984	
Bird	RALLUS LIMICOLA	VIRGINIA RAIL	SE	**	033N006E 033N006E	26 27	SWQ SWQ SWQ NWQ SEQ SEQ	1992	
Reptile	EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	SE	**	033N006E	26	SWQ	1984	
High Quality Community	WETLAND - BEACH MARL	MARL BEACH	SG	**	033N006E 033N006E	26 27	SWQ SEQ	1983	
High Quality Community	WETLAND - MARSH	MARSH	SG	**	033N006E 033N006E	27 26	SEQ SWQ	1982	
High Quality Community	WETLAND - MEADOW SEDGE	SEDGE MEADOW	SG	**	033N006E 033N006E	27 26	SEQ SWQ	1982	
High Quality Community	WETLAND - SWAMP SHRUB	SHRUB SWAMP	SG	**	033N006E 033N006E	27 26	SEQ SWQ	1982	
LITTLE CHAPMAN LAKE NATURE PRESERVE	(DNR FISH AND WILDLIFE - DNR NATURE PRESERVES)								
Bird	CISTOTHORUS PALUSTRIS	MARSH WREN	SE	**	033N006E	35	NWQ	1990	
Bird	IXOBRYCHUS EXILIS	LEAST BITTERN	SE	**	033N006E	35	NWQ	1990	
Bird	MNIOTILTA VARIA	BLACK-AND-WHITE WARBLER	SSC	**	033N006E	35	NWQ	1990	
Bird	NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON	SE	**	033N006E	35	NWQ	1984	
Bird	RALLUS ELEGANS	KING RAIL	SE	**	033N006E	35	NWQ	1984	
Bird	RALLUS LIMICOLA	VIRGINIA RAIL	SE	**	033N006E	35	NWQ	1984	
Bird	VERMIVORA CHRYSOPTERA	GOLDEN-WINGED WARBLER	SE	**	033N006E	35	NWQ	1984	
Reptile	EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	SE	**	033N006E	35	NWQ	1986	
High Quality Community	WETLAND - BOG CIRCUMNEUTRAL	CIRCUMNEUTRAL BOG	SG	**	033N006E	35	NWQ	1983	
High Quality Community	WETLAND - MARSH	MARSH	SG	**	033N006E	35	NWQ	1997	
High Quality Community	WETLAND - MEADOW SEDGE	SEDGE MEADOW	SG	**	033N006E	35	NWQ	1997	
Plant	ERIOPHORUM VIRIDICARINATUM	GREEN-KEELED COTTON-GRASS	SR	**	033N006E	35	SEQ NWQ	1983	

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant, SRE=sta reintroduced

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangere PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

APPENDIX 4:

Endangered, Threatened, and Rare
Species List,
Kosciusko County

November 12, 1999

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM KOSCIUSKO COUNTY, INDIANA

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
VASCULAR PLANT					
ACTAEA RUBRA	RED BANEBERRY	SR	**	S2	G5
ANDROMEDA GLAUCOPHYLLA	BOG ROSEMARY	SR	**	S2	G5
ARETHUSA BULBOSA	SWAMP-PINK	SX	**	SX	G4
ASTER BOREALIS	RUSHLIKE ASTER	SR	**	S2	G5
BIDENS BECKII	BECK WATER-MARIGOLD	SE	**	S1	G4G5T4
CAREX AUREA	GOLDEN-FRUITED SEDGE	SR	**	S2	G5
CAREX BEBBII	BEBB'S SEDGE	ST	**	S2	G5
CAREX CHORDORRHIZA	CREEPING SEDGE	SE	**	S1	G5
CAREX DISPERMA	SOFTLEAF SEDGE	SE	**	S1	G5
CAREX ECHINATA	LITTLE PRICKLY SEDGE	SE	**	S1	G5
CAREX FLAVA	YELLOW SEDGE	ST	**	S2	G5
CAREX PSEUDOCYPERUS	CYPERUS-LIKE SEDGE	SE	**	S1	G5
CORNUS AMOMUM SSP AMOMUM	SILKY DOGWOOD	SE	**	S1	G5T?
CORNUS CANADENSIS	BUNCHBERRY	SE	**	S1	G5
CYPRIPEDIUM CALCEOLUS VAR PARVIFLORUM	SMALL YELLOW LADY'S-SLIPPER	SR	**	S2	G5
CYPRIPEDIUM CANDIDUM	SMALL WHITE LADY'S-SLIPPER	SR	**	S2	G4
DROSERA INTERMEDIA	SPOON-LEAVED SUNDEW	SR	**	S2	G5
ELEOCHARIS GENICULATA	CAPITATE SPIKE-RUSH	ST	**	S2	G5
ERIOPHORUM ANGUSTIFOLIUM	NARROW-LEAVED COTTON-GRASS	SR	**	S2	G5
ERIOPHORUM GRACILE	SLENDER COTTON-GRASS	ST	**	S2	G5
ERIOPHORUM VIRIDICARINATUM	GREEN-KEELED COTTON-GRASS	SR	**	S2	G5
GERANIUM ROBERTIANUM	HERB-ROBERT	ST	**	S2	G5
JUGLANS CINEREA	BUTTERNUT	WL	**	S3	G3G4
LATHYRUS OCHROLEUCUS	PALE VETCHLING PEAVINE	SE	**	S1	G4G5
LEMNA PERPUSILLA	MINUTE DUCKWEED	SX	**	SX	G5
MALAXIS UNIFOLIA	GREEN ADDER'S-MOUTH	SE	**	S1	G5
MATTEUCCIA STRUTHIOPTERIS	OSTRICH FERN	SR	**	S2	G5
MYRIOPHYLLUM VERTICILLATUM	WHORLED WATER-MILFOIL	ST	**	S2	G5
PANICUM BOREALE	NORTHERN WITCHGRASS	SR	**	S2	G5
PLATANTHERA PSYCODES	SMALL PURPLE-FRINGE ORCHIS	SR	**	S2	G5
POTAMOGETON EPIHYDRUS	NUTTALL PONDWEED	SE	**	S1	G5
POTAMOGETON FRIESII	FRIES' PONDWEED	SE	**	S1	G4
POTAMOGETON OAKESIANUS	OAKES PONDWEED	SE	**	S1	G4
POTAMOGETON RICHARDSONII	REDHEADGRASS	ST	**	S2	G5
POTAMOGETON STRICTIFOLIUS	STRAIGHT-LEAF PONDWEED	SE	**	S1	G5
PRUNUS PENSYLVANICA	FIRE CHERRY	SR	**	S2	G5
SCIRPUS SUBTERMINALIS	WATER BULRUSH	SR	**	S2	G4G5
SELAGINELLA APODA	MEADOW SPIKE-MOSS	SE	**	S1	G5
SPARGANIUM ANDROCLADUM	BRANCHING BUR-REED	ST	**	S2	G4G5
SPIRANTHES LUCIDA	SHINING LADIES'-TRESSES	SR	**	S2	G5
STENANTHIUM GRAMINEUM	EASTERN FEATHERBELLS	SE	**	S1	G4G5
TOFIELDIA GLUTINOSA	FALSE ASPHODEL	SR	**	S2	G5

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but rarity warrants concern

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered, PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM KOSCIUSKO COUNTY, INDIANA

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
UTRICULARIA RESUPINATA	NORTHEASTERN BLADDERWORT	SX	**	SX	G4
VACCINIUM OXYCOCCOS	SMALL CRANBERRY	ST	**	S2	G5
WOLFFIELLA FLORIDANA	SWORD BOGMAT	SX	**	SX	G5
ZANNICHELLIA PALUSTRIS	HORNED PONDWEED	SE	**	S1	G5
ZIGADENUS ELEGANS VAR GLAUCUS	WHITE CAMAS	SR	**	S2	G5T4T5
MOLLUSCA: BIVALVIA (MUSSELS)					
ALASMIDONTA VIRIDIS	SLIPPERSHELL MUSSEL	**	**	S2	G4G5
EPIOBLASMA OBLIQUATA PEROBLIQUA	WHITE CAT'S PAW PEARLYMUSSEL	SE	LE	S1	G1T1
EPIOBLASMA TORULOSA RANGIANA	NORTHERN RIFFLESHELL	SE	LE	S1	G2T2
LAMPSILIS FASCIOLA	WAVY-RAYED LAMPMUSSEL	SSC	**	S2	G4
LAMPSILIS OVATA	POCKETBOOK	**	**	S2	G5
LIGUMIA RECTA	BLACK SANDSHELL	**	**	S2	G5
PLEUROBEMA CLAVA	CLUBSHELL	SE	LE	S1	G2
PTYCHOBRANCHUS FASCIOLARIS	KIDNEYSHELL	SSC	**	S2	G4G5
QUADRULA CYLINDRICA CYLINDRICA	RABBITSFOOT	SE	**	S1	G3T3
TOXOLASMA LIVIDUS	PURPLE LILLIPUT	SSC	**	S2	G2
TOXOLASMA PARVUM	LILLIPUT	**	**	S2	G5
VILLOSA FABALIS	RAYED BEAN	SSC	**	S1	G1G2
VILLOSA LIENOSA	LITTLE SPECTACLECASE	SSC	**	S2	G5
ARTHROPODA: INSECTA: LEPIDOPTERA (BUTTERFLIES; SKIPPERS)					
EUPHYDRYAS PHAETON	BALTIMORE	**	**	S2S4	G4
EUPHYES BIMACULA	TWO-SPOTTED SKIPPER	SR	**	S2	G4
EURISTRYMON ONTARIO	NORTHERN HAIRSTREAK	WL	**	S2S4	G4
HESPERIA LEONARDUS	LEONARDUS SKIPPER	SR	**	S2	G4
LYCAENA HELLOIDES	PURPLISH COPPER	**	**	S2S4	G5
PIERIS OLERACEA	VEINED WHITE	SE	**	S1	G5T4
ARTHROPODA: INSECTA: LEPIDOPTERA (MOTHS)					
HEMILEUCA SP 3	MIDWESTERN FEN BUCKMOTH	**	**	S1?	G3G4
LYTROSIS PERMAGNARIA	A LYTROSIS MOTH	ST	**	S2	GU
FISH					
ACIPENSER FULVESCENS	LAKE STURGEON	SE	**	S1	G3
COREGONUS ARTEDI	CISCO	SSC	**	S2	G5
HYBOPSIS AMBLOPS	BIGEYE CHUB	**	**	S2	G5
NOTROPIS HETEROLEPIS	BLACKNOSE SHINER	**	**	S2	G5
PERCINA EVIDES	GILT DARTER	SE	**	S1	G4
AMPHIBIANS					
AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER	SSC	**	S2	G5
HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER	SE	**	S2	G5

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but rarity warrants concern

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered, PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM KOSCIUSKO COUNTY, INDIANA

SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
NECTURUS MACULOSUS	MUDPUPPY	SSC	**	S2	G5
RANA PIPIENS	NORTHERN LEOPARD FROG	SSC	**	S2	G5
REPTILES					
CLEMMYS GUTTATA	SPOTTED TURTLE	SE	**	S2	G5
CLONOPHIS KIRTLANDII	KIRTLAND'S SNAKE	SE	**	S2	G2
EMYDOIDEA BLANDINGII	BLANDING'S TURTLE	SE	**	S2	G4
NERODIA ERYTHROGASTER NEGLECTA	COPPERBELLY WATER SNAKE	SE	**	S2	G5T2T3
SISTRURUS CATENATUS CATENATUS	EASTERN MASSASAUGA	SE	**	S2	G3G4T3T4
BIRDS					
ACCIPITER COOPERII	COOPER'S HAWK	**	**	S3B,SZN	G5
ARDEA HERODIAS	GREAT BLUE HERON	**	**	S4B,SZN	G5
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	SE	**	S2B	G4
CHLIDONIAS NIGER	BLACK TERN	SE	**	S1B,SZN	G4
CIRCUS CYANEUS	NORTHERN HARRIER	SE	**	S2	G5
CISTOTHORUS PALUSTRIS	MARSH WREN	SE	**	S3B,SZN	G5
CISTOTHORUS PLATENSIS	SEDGE WREN	SE	**	S3B,SZN	G5
DENDROICA CERULEA	CERULEAN WARBLER	SSC	**	S3B	G4
FALCO PEREGRINUS	PEREGRINE FALCON	SE	E(S/A)	S2B,SZN	G4
GRUS CANADENSIS	SANDHILL CRANE	SE	**	S2B,S1N	G5
IXOBRYCHUS EXILIS	LEAST BITTERN	SE	**	S3B	G5
MNIOTILTA VARIA	BLACK-AND-WHITE WARBLER	SSC	**	S1S2B	G5
NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON	SE	**	S1B,SAN	G5
RALLUS ELEGANS	KING RAIL	SE	**	S1B,SZN	G4G5
RALLUS LIMICOLA	VIRGINIA RAIL	SSC	**	S3B,SZN	G5
VERMIVORA CHRYSOPTERA	GOLDEN-WINGED WARBLER	SE	**	S1B	G4
MAMMALS					
CONDYLURA CRISTATA	STAR-NOSED MOLE	SSC	**	S2?	G5
LUTRA CANADENSIS	NORTHERN RIVER OTTER	SE	**	S?	G5
MUSTELA NIVALIS	LEAST WEASEL	SSC	**	S2?	G5
MYOTIS SODALIS	INDIANA BAT OR SOCIAL MYOTIS	SE	LE	S1	G2
TAXIDEA TAXUS	AMERICAN BADGER	SE	**	S2	G5
HIGH QUALITY NATURAL COMMUNITY					
FOREST - UPLAND DRY-MESIC	DRY-MESIC UPLAND FOREST	SG	**	S4	G4
FOREST - UPLAND MESIC	MESIC UPLAND FOREST	SG	**	S3	G3?
LAKE - LAKE	LAKE	SG	**	S2	
WETLAND - BEACH MARL	MARL BEACH	SG	**	S2	G3
WETLAND - BOG ACID	ACID BOG	SG	**	S2	G3
WETLAND - BOG CIRCUMNEUTRAL	CIRCUMNEUTRAL BOG	SG	**	S3	G3
WETLAND - FEN	FEN	SG	**	S3	G3

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but rarity warrants concern

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered, PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

ENDANGERED, THREATENED AND RARE SPECIES DOCUMENTED FROM KOSCIUSKO COUNTY, INDIANA

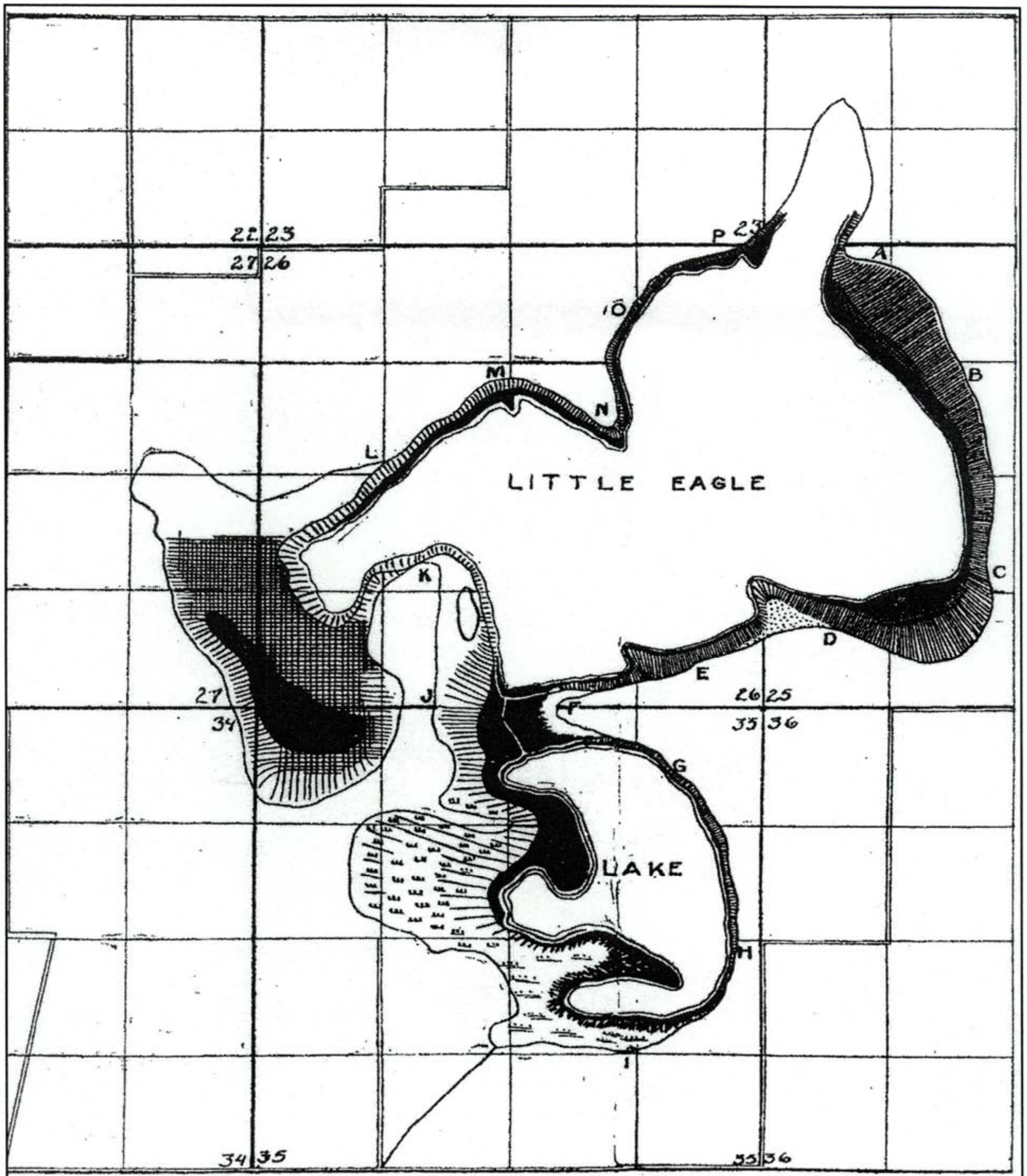
SPECIES NAME	COMMON NAME	STATE	FED	SRANK	GRANK
WETLAND - FEN FORESTED	FORESTED FEN	SG	**	S1	G3
WETLAND - MARSH	MARSH	SG	**	S4	GU
WETLAND - MEADOW SEDGE	SEDGE MEADOW	SG	**	S1	G3?
WETLAND - SWAMP SHRUB	SHRUB SWAMP	SG	**	S2	GU

STATE: SX=extirpated, SE=endangered, ST=threatened, SR=rare, SSC=special concern, WL=watch list, SG=significant,** no status but rarity warrants concern

FEDERAL: LE=endangered, LT=threatened, LELT=different listings for specific ranges of species, PE=proposed endangered, PT=proposed threatened, E/SA=appearance similar to LE species, **=not listed

APPENDIX 5:

Historical Maps and Aerial Photographs
Around Big and Little Chapman Lakes

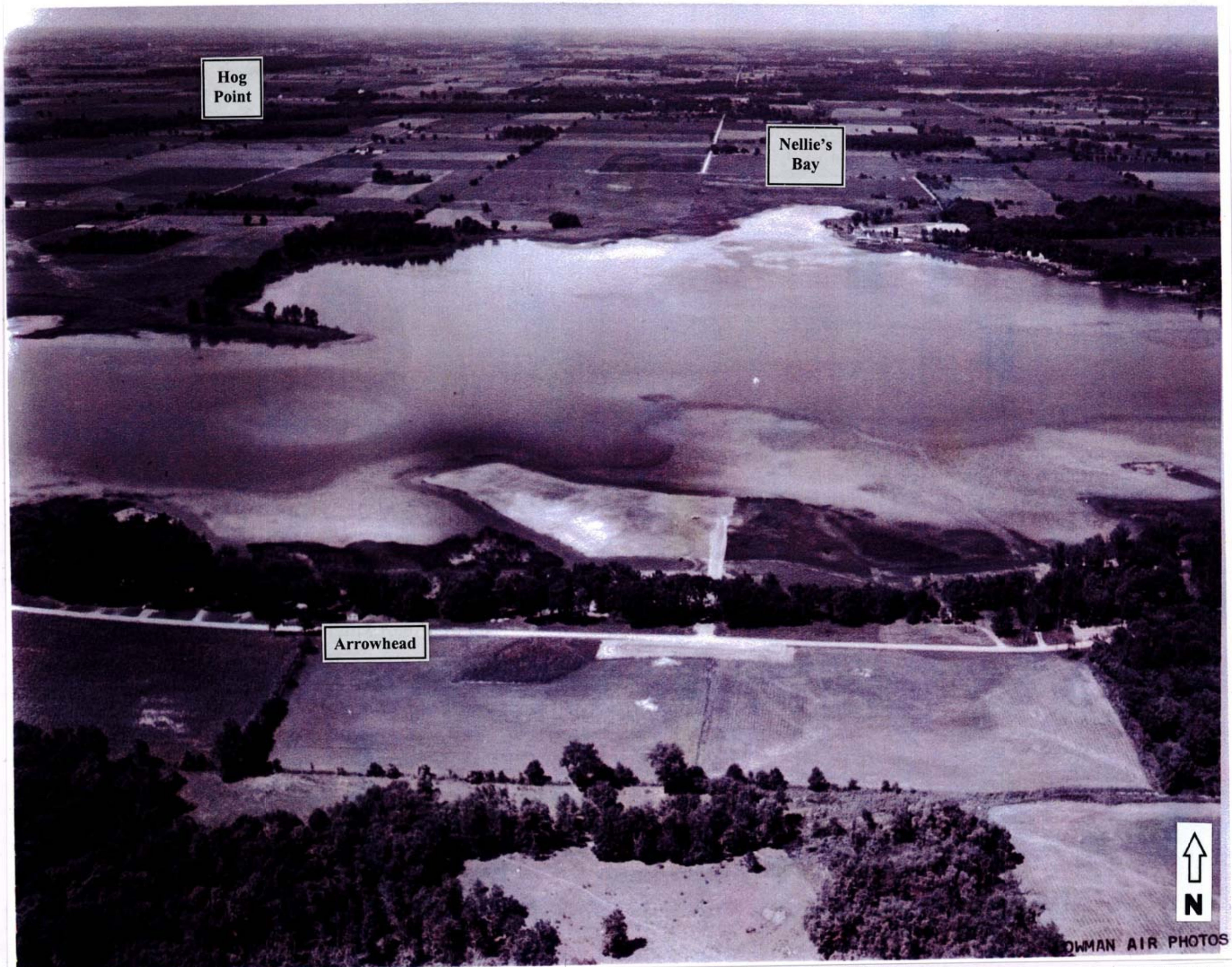


Map of Little Eagle Lake, Kosciusko County, Ind.

Source: (Blatchley, 1900)

JFNA #99-04-01

1938 aerial photograph of Big Chapman Lake and part of Little Chapman Lake. Photo is courtesy of the Indiana State Library.



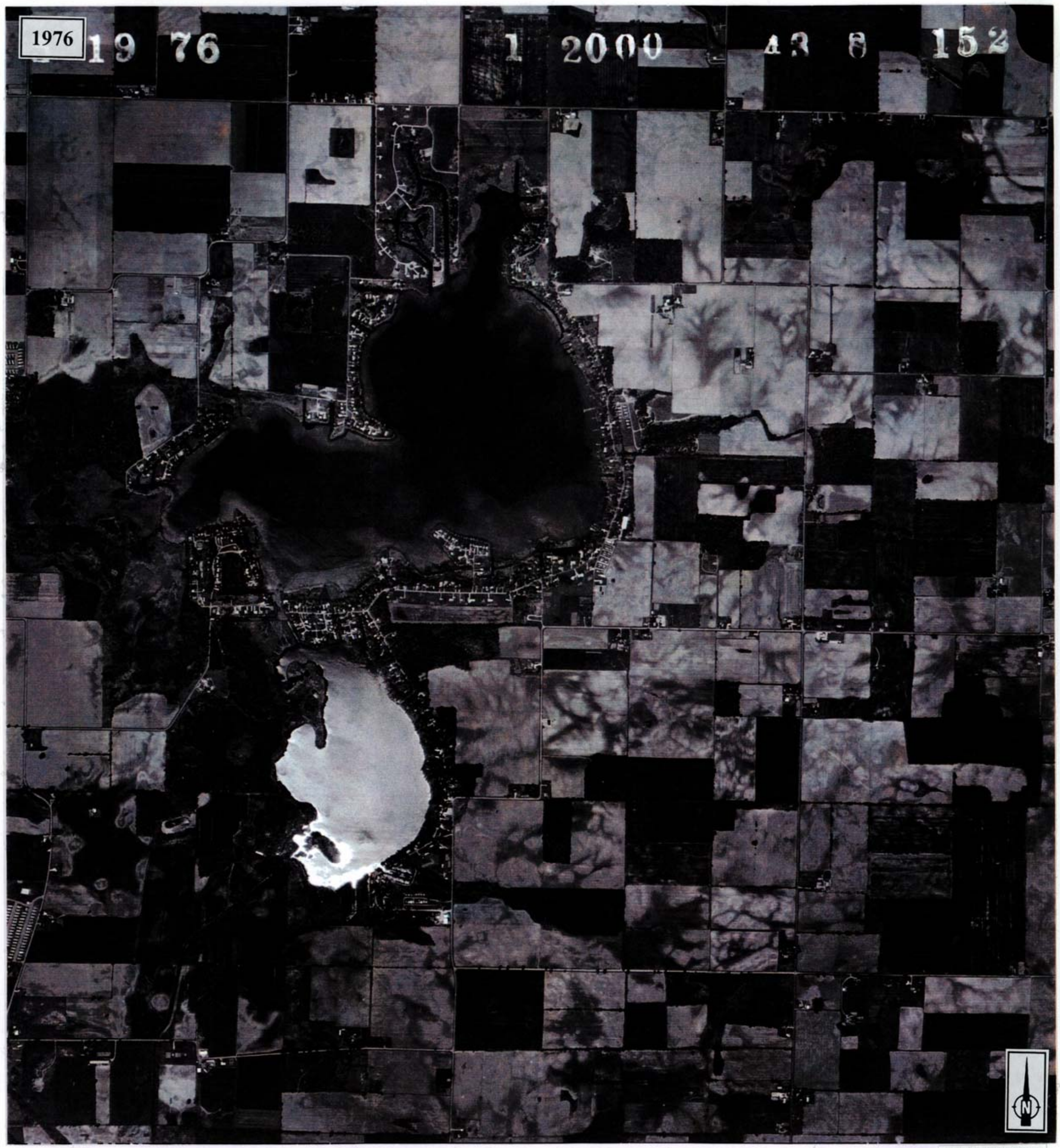
JFNA #99-04-01

Late 1940s aerial photograph of the northern half and northwestern shoreline of Big Chapman Lake. Photo is courtesy of Pete Smith.

JFNA #99-04-01

Late 1940s aerial photograph of the most western shoreline of Big Chapman Lake. Photo is courtesy of Pete Smith.

1957 aerial photograph of Big Chapman and Little Chapman Lakes. Photo is courtesy of the Indiana State Library.

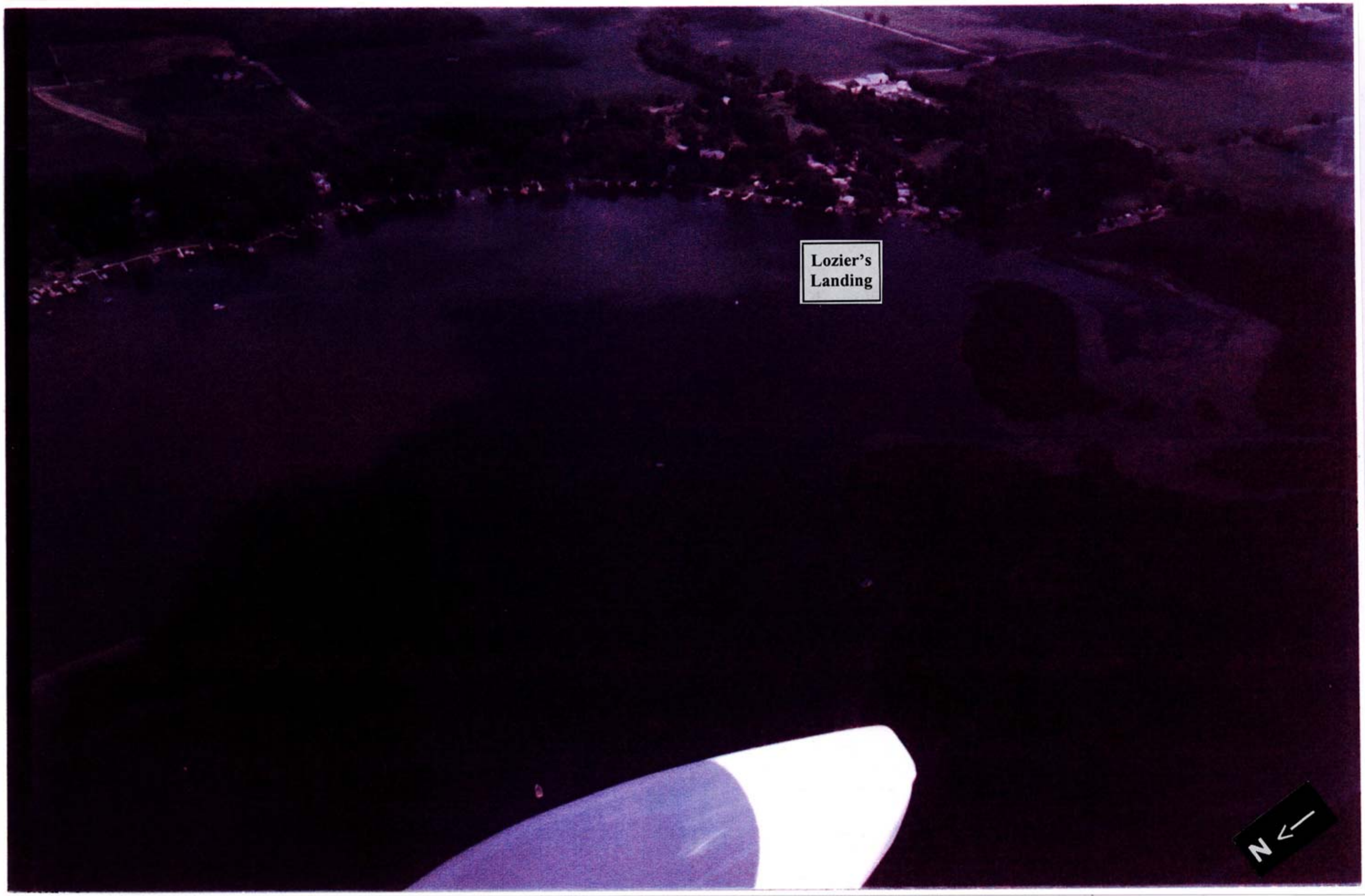


JFNA #99-04-01

1976 aerial photograph of Big Chapman and Little Chapman Lakes. Photo is courtesy of the Indiana Department of Transportation.

JFNA #99-04-01

August 4, 2000 aerial photograph of the northern half of Big Chapman Lake. Photo is courtesy of Dan Lee.



August 4, 2000 aerial photograph of the south end and southeast shoreline of Little Chapman Lake. Photo is courtesy of Dan Lee.

JFNA #99-04-01

APPENDIX 6:

Stream Sampling
Laboratory Data Sheets

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

BASE

Customer: 471

J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Sample: 126520
Description: 1 INLET SE CORNER LK
Desc Code: STUDY
Sampled: 10/12/00 Time:
Received: 10/12/00
Reported: 10/31/00 10:46 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Conductivity		650.00	uMho		2510B	10/17/00	20:30	59882	JAS		
QC-Conductivity		650.00	uMho		2510B	10/17/00	20:30	59882	JAS	DUP	
				Reference Method: 2510 B Conductivity Electrometric							
Suspended Solids	<	1.00	mg/L	1.00	2540D	10/16/00	19:30	59884	EM		None Detected
				Reference Method: 2540 D Total Suspended Solids Dried at 103 C							
Nitrate-Nitrite/N		5.00	mg/L		353.2	10/23/00	21:20	59895	SB		
				Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method							
pH value		8.03	unit		4500HB	10/12/00	18:45	59619	EM		
				Reference Method: 4500 H B pH Electrometric Method							
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	10/20/00	09:20	59836	EM		None Detected
				Reference Method: 4500 NH3 F Ammonia Selective Electrode							
Kjeldahl Nitrogen	<	.40	mg/L	.05	4500NORGB	10/18/00	10:15	59809	JAS		None Detected
				Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method							
Phosphorus Total		.03	mg/L	.01	4500PB5E	10/27/00	15:30	59962	JAS		
				Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid							
Phosphorus Ortho	<	.02	mg/L	.01	4500PE	10/13/00	13:00	59433	JAS		None Detected
				Reference Method: 4500 P E Ascorbic Acid							

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates
708 Roosevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Sample: 126521
Description: 2 INLET/ARROWHEAD PK
Desc Code: STUDY
Sampled: 10/12/00 Time:
Received: 10/12/00
Reported: 10/31/00 10:46 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Conductivity		670.00	uMho		2510B	10/17/00	20:30	59882	JAS		
					Reference Method: 2510 B Conductivity Electrometric						
Suspended Solids		4.00	mg/L	1.00	2540D	10/16/00	19:30	59884	EM		
					Reference Method: 2540 D Total Suspended Solids Dried at 103 C						
Nitrate-Nitrite/N		4.20	mg/L		353.2	10/23/00	21:20	59895	SB		
					Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method						
pH value		8.02	unit		4500HB	10/12/00	18:45	59619	EM		
					Reference Method: 4500 H B pH Electrometric Method						
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	10/20/00	09:20	59836	EM		None Detected
					Reference Method: 4500 NH3 F Ammonia Selective Electrode						
Kjeldahl Nitrogen		.40	mg/L	.05	4500NORGB	10/18/00	10:15	59809	JAS		
					Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method						
Phosphorus Total		.03	mg/L	.01	4500PB5E	10/27/00	15:30	59962	JAS		
					Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid						
Phosphorus Ortho		.02	mg/L	.01	4500PE	10/13/00	13:00	59433	JAS		
					Reference Method: 4500 P E Ascorbic Acid						

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Sample: 126522
Description: 3 INLET/CAMPGROUND
Desc Code: STUDY
Sampled: 10/12/00 Time:
Received: 10/12/00
Reported: 10/31/00 10:46 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Conductivity		670.00	uMho		2510B	10/17/00	20:30	59882	JAS		
				Reference Method: 2510 B Conductivity Electrometric							
Suspended Solids	<	1.00	mg/L	1.00	2540D	10/16/00	19:30	59884	EM		None Detected
				Reference Method: 2540 D Total Suspended Solids Dried at 103 C							
Nitrate-Nitrite/N		3.20	mg/L		353.2	10/23/00	21:20	59895	SB		
				Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method							
pH value		8.12	unit		4500HB	10/12/00	18:45	59619	EM		
QC-pH value		8.12	unit		4500HB	10/12/00	18:45	59619	EM	DUP	
				Reference Method: 4500 H B pH Electrometric Method							
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	10/20/00	09:20	59836	EM		None Detected
				Reference Method: 4500 NH3 F Ammonia Selective Electrode							
Kjeldahl Nitrogen	<	.40	mg/L	.05	4500NORGB	10/18/00	10:15	59809	JAS		None Detected
				Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method							
Phosphorus Total		.05	mg/L	.01	4500PB5E	10/27/00	15:30	59962	JAS		
				Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid							
Phosphorus Ortho		.03	mg/L	.01	4500PE	10/13/00	13:00	59433	JAS		
				Reference Method: 4500 P E Ascorbic Acid							

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659

Customer: 471

J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Billing: J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Sample: 126523
Description: 4 INLET/ISLAND PARK
Desc Code: STUDY
Sampled: 10/12/00 Time:
Received: 10/12/00
Reported: 10/31/00 10:46 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Conductivity		400.00	uMho		2510B	10/17/00	20:30	59882	JAS		
				Reference Method: 2510 B Conductivity Electrometric							
Suspended Solids		5.00	mg/L	1.00	2540D	10/16/00	19:30	59884	EM		
				Reference Method: 2540 D Total Suspended Solids Dried at 103 C							
Nitrate-Nitrite/N		.28	mg/L		353.2	10/23/00	21:20	59895	SB		
QC-Nitrate-Nitrite/N		.24	mg/L		353.2	10/23/00	21:20	59895	SB	DUP	
QC-Nitrate-Nitrite/N		2.28	mg/L		353.2	10/23/00	21:20	59895	SB	SPK 2.00	
				Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method							
pH value		7.20	unit		4500HB	10/12/00	18:45	59619	EM		
				Reference Method: 4500 H B pH Electrometric Method							
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	10/20/00	09:20	59836	EM		None Detected
				Reference Method: 4500 NH3 F Ammonia Selective Electrode							
Kjeldahl Nitrogen		2.40	mg/L	.05	4500NORGB	10/18/00	10:15	59809	JAS		
QC-Kjeldahl Nitrogen		2.50	mg/L	.05	4500NORGB	10/18/00	10:15	59809	JAS	DUP	
				Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method							
Phosphorus Total		.05	mg/L	.01	4500PB5E	10/27/00	15:30	59962	JAS		
				Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid							
Phosphorus Ortho	<	.02	mg/L	.01	4500PE	10/13/00	13:00	59433	JAS		None Detected
				Reference Method: 4500 P E Ascorbic Acid							

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Sample: 126524
Description: 5 OUTLET
Desc Code: STUDY
Sampled: 10/12/00 Time:
Received: 10/12/00
Reported: 10/31/00 10:46 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Conductivity		740.00	uMho		2510B	10/17/00	20:30	59882	JAS		
				Reference Method: 2510 B Conductivity Electrometric							
Suspended Solids		2.00	mg/L	1.00	2540D	10/16/00	19:30	59884	EM		
				Reference Method: 2540 D Total Suspended Solids Dried at 103 C							
Nitrate-Nitrite/N		.74	mg/L		353.2	10/23/00	21:20	59895	SB		
				Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method							
pH value		7.59	unit		4500HB	10/12/00	18:45	59619	EM		
				Reference Method: 4500 H B pH Electrometric Method							
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	10/20/00	11:15	59859	EM		None Detected
				Reference Method: 4500 NH3 F Ammonia Selective Electrode							
Kjeldahl Nitrogen		.54	mg/L	.05	4500NORGB	10/18/00	10:15	59809	JAS		
				Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method							
Phosphorus Total		.02	mg/L	.01	4500PB5E	10/27/00	15:30	59962	JAS		
				Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid							
Phosphorus Ortho	<	.02	mg/L	.01	4500PE	10/13/00	13:00	59433	JAS		None Detected
				Reference Method: 4500 P E Ascorbic Acid							

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Roosevelt Rd
Walkerton, IN 46574

Sample: 126525
Description: 6 INLET/HIGHLANDS PK
Desc Code: STUDY
Sampled: 10/12/00 Time:
Received: 10/12/00
Reported: 10/31/00 10:46 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Conductivity		720.00	uMho		2510B	10/17/00	20:30	59882	JAS		
					Reference Method: 2510 B Conductivity Electrometric						
Suspended Solids		2.00	mg/L	1.00	2540D	10/16/00	19:30	59884	EM		
					Reference Method: 2540 D Total Suspended Solids Dried at 103 C						
Nitrate-Nitrite/N		.74	mg/L		353.2	10/23/00	21:20	59895	SB		
					Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method						
pH value		7.95	unit		4500HB	10/12/00	18:45	59619	EM		
					Reference Method: 4500 H B pH Electrometric Method						
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	10/20/00	11:15	59859	EM		None Detected
					Reference Method: 4500 NH3 F Ammonia Selective Electrode						
Kjeldahl Nitrogen	<	.40	mg/L	.05	4500NORGB	10/18/00	10:15	59809	JAS		None Detected
					Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method						
Phosphorus Total		.04	mg/L	.01	4500PB5E	10/27/00	15:30	59962	JAS		
					Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid						
Phosphorus Ortho		.04	mg/L	.01	4500PE	10/13/00	13:00	59433	JAS		
					Reference Method: 4500 P E Ascorbic Acid						

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

STORM

Customer: 471

J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Sample: 125378
Description: #1 INLET SE CORNER
Desc Code: SILVER
Sampled: 9/12/00 Time:
Received: 9/12/00
Reported: 10/03/00 11:57 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Turbidity		9.84	NTU	.50	180.1	9/19/00	11:00	59592	SB		
					Reference Method: 2130 B Nephelometric Method						
Conductivity		380.00	uMho		2510B	9/13/00	13:40	59555	JAS		
					Reference Method: 2510 B Conductivity Electrometric						
Suspended Solids		12.00	mg/L	1.00	2540D	9/14/00	09:20	59559	EM		
					Reference Method: 2540 D Total Suspended Solids Dried at 103 C						
Nitrate-Nitrite/N		4.20	mg/L		353.2	9/29/00	15:30	59378	SB		
					Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method						
pH value		7.45	unit		4500HB	9/12/00	16:50	59404	EM		
					Reference Method: 4500 H B pH Electrometric Method						
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	9/25/00	11:15	59397	EM		None Detected
					Reference Method: 4500 NH3 F Ammonia Selective Electrode						
Kjeldahl Nitrogen		1.40	mg/L	.05	4500NORGB	9/20/00	10:40	59575	EM		
					Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method						
Phosphorus Total		.43	mg/L	.01	4500PB5E	9/15/00	14:30	59613	JAS		
					Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid						
Phosphorus Ortho		.28	mg/L	.01	4500PE	9/13/00	14:00	59554	JAS		
					Reference Method: 4500 P E Ascorbic Acid						
E Coli Beaches		16,000.00	/100		9213D	9/13/00	13:00	59050	KK		
					Reference Method: 9213 D Natural Bathing Beach Escherichia coli						

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Sample: 125379
Description: #2 INLET E SIDE
Desc Code: SILVER
Sampled: 9/12/00 Time:
Received: 9/12/00
Reported: 10/03/00 11:57 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Turbidity		7.39	NTU	.50	180.1	9/19/00	11:00	59592	SB		
				Reference Method: 2130 B Nephelometric Method							
Conductivity		530.00	uMho		2510B	9/13/00	13:40	59555	JAS		
				Reference Method: 2510 B Conductivity Electrometric							
Suspended Solids		7.00	mg/L	1.00	2540D	9/14/00	09:20	59559	EM		
				Reference Method: 2540 D Total Suspended Solids Dried at 103 C							
Nitrate-Nitrite/N		4.00	mg/L		353.2	9/29/00	15:30	59378	SB		
				Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method							
pH value		7.68	unit		4500HB	9/12/00	16:50	59404	EM		
QC-pH value		7.68	unit		4500HB	9/12/00	16:50	59404	EM	DUP	
				Reference Method: 4500 H B pH Electrometric Method							
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	9/25/00	11:15	59397	EM		None Detected
				Reference Method: 4500 NH3 F Ammonia Selective Electrode							
Kjeldahl Nitrogen		.95	mg/L	.05	4500NORGB	9/20/00	10:40	59575	EM		
				Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method							
Phosphorus Total		.29	mg/L	.01	4500PB5E	9/15/00	14:30	59613	JAS		
				Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid							
Phosphorus Ortho		.07	mg/L	.01	4500PE	9/13/00	14:00	59554	JAS		
				Reference Method: 4500 P E Ascorbic Acid							
E Coli Beaches		14,000.00	/100		9213D	9/13/00	13:00	59050	KK		
				Reference Method: 9213 D Natural Bathing Beach Escherichia coli							

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Sample: 125380
Description: #3 INLET NE SIDE
Desc Code: SILVER
Sampled: 9/12/00 Time:
Received: 9/12/00
Reported: 10/03/00 11:57 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Turbidity		11.00	NTU	.50	180.1	9/19/00	11:00	59592	SB		
					Reference Method: 2130 B Nephelometric Method						
Conductivity		395.00	uMho		2510B	9/13/00	13:40	59555	JAS		
QC-Conductivity		395.00	uMho		2510B	9/13/00	13:40	59555	JAS	DUP	
					Reference Method: 2510 B Conductivity Electrometric						
Suspended Solids		34.00	mg/L	1.00	2540D	9/14/00	09:20	59559	EM		
					Reference Method: 2540 D Total Suspended Solids Dried at 103 C						
Nitrate-Nitrite/N		2.84	mg/L		353.2	9/29/00	15:30	59378	SB		
					Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method						
pH value		7.66	unit		4500HB	9/12/00	16:50	59404	EM		
					Reference Method: 4500 H B pH Electrometric Method						
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	9/25/00	11:15	59397	EM		None Detected
QC-Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	9/25/00	11:15	59397	EM	DUP	None Detected
QC-Ammonia Nitrogen		.51	mg/L	.10	4500NH3F	9/25/00	11:15	59397	EM	SPK .5	
					Reference Method: 4500 NH3 F Ammonia Selective Electrode						
Kjeldahl Nitrogen		1.20	mg/L	.05	4500NORGB	9/20/00	10:40	59575	EM		
					Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method						
Phosphorus Total		.40	mg/L	.01	4500PB5E	9/15/00	14:30	59613	JAS		
					Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid						
Phosphorus Ortho		.18	mg/L	.01	4500PE	9/13/00	14:00	59554	JAS		
					Reference Method: 4500 P E Ascorbic Acid						
E Coli Beaches		23,300.00	/100		9213D	9/13/00	13:00	59050	KK		
					Reference Method: 9213 D Natural Bathing Beach Escherichia coli						

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Sample: 125381
Description: #4 INLET W SIDE
Desc Code: SILVER
Sampled: 9/12/00 Time:
Received: 9/12/00
Reported: 10/03/00 11:57 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Turbidity		3.41	NTU	.50	180.1	9/19/00	11:00	59592	SB		
				Reference Method: 2130 B Nephelometric Method							
Conductivity		200.00	uMho		2510B	9/13/00	13:40	59555	JAS		
				Reference Method: 2510 B Conductivity Electrometric							
Suspended Solids		10.00	mg/L	1.00	2540D	9/14/00	09:20	59559	EM		
				Reference Method: 2540 D Total Suspended Solids Dried at 103 C							
Nitrate-Nitrite/N		1.22	mg/L		353.2	9/29/00	15:30	59378	SB		
				Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method							
pH value		6.92	unit		4500HB	9/12/00	16:50	59404	EM		
				Reference Method: 4500 H B pH Electrometric Method							
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	9/25/00	11:15	59397	EM		None Detected
				Reference Method: 4500 NH3 F Ammonia Selective Electrode							
Kjeldahl Nitrogen		1.80	mg/L	.05	4500NORGB	9/20/00	10:40	59575	EM		
				Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method							
Phosphorus Total		.21	mg/L	.01	4500PB5E	9/15/00	14:30	59613	JAS		
				Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid							
Phosphorus Ortho		.06	mg/L	.01	4500PE	9/13/00	14:00	59554	JAS		
				Reference Method: 4500 P E Ascorbic Acid							
E Coli Beaches		22,300.00	/100		9213D	9/13/00	13:00	59050	KK		
				Reference Method: 9213 D Natural Bathing Beach Escherichia coli							

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

LABORATORY REPORT

Turner Technologies, Inc.

560 Zimmer Road - P.O. Box 1096
Warsaw, Indiana 46581-1096
Voice 219/267-3305 Fax 219/269-6569
Certified Public Health Laboratory #: MC-43-1
USDA Laboratory Code#: 3659
Billing: J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Customer: 471

J. F. New & Associates

708 Rossevelt Rd
Walkerton, IN 46574

Sample: 125382
Description: #5 DISCHARGE-CHAPMAN
Desc Code: SILVER
Sampled: 9/12/00 Time:
Received: 9/12/00
Reported: 10/03/00 11:57 am
P.O. Number:

Test Description		RESULT	Units	Detection Limit	Our Lab's Method	Date Tested	Time	Run #	Analyst	QC Data	Comments
Turbidity		4.00	NTU	.50	180.1	9/19/00	11:00	59592	SB		
					Reference Method: 2130 B Nephelometric Method						
Conductivity		360.00	uMho		2510B	9/13/00	13:40	59555	JAS		
					Reference Method: 2510 B Conductivity Electrometric						
Suspended Solids		14.00	mg/L	1.00	2540D	9/14/00	09:20	59559	EM		
QC-Suspended Solids		14.00	mg/L	1.00	2540D	9/14/00	09:20	59559	EM	DUP	
					Reference Method: 2540 D Total Suspended Solids Dried at 103 C						
Nitrate-Nitrite/N		1.58	mg/L		353.2	9/29/00	15:30	59378	SB		
					Reference Method: 4500 NO3 D Nitrate Nitrogen Electrode Method						
pH value		7.56	unit		4500HB	9/12/00	16:50	59404	EM		
					Reference Method: 4500 H B pH Electrometric Method						
Ammonia Nitrogen	<	.10	mg/L	.10	4500NH3F	9/25/00	11:15	59397	EM		None Detected
					Reference Method: 4500 NH3 F Ammonia Selective Electrode						
Kjeldahl Nitrogen		1.10	mg/L	.05	4500NORGB	9/20/00	10:40	59575	EM		
QC-Kjeldahl Nitrogen		1.20	mg/L	.05	4500NORGB	9/20/00	10:40	59575	EM	DUP	
					Reference Method: 4500 NORG B Nitrogen Macro-Kjeldahl Method						
Phosphorus Total		.21	mg/L	.01	4500PB5E	9/15/00	14:30	59613	JAS		
					Reference Method: 4500 P B 5 E H2SO4-HNO3, Ascorbic Acid						
Phosphorus Ortho	<	.02	mg/L	.01	4500PE	9/13/00	14:00	59554	JAS		None Detected
QC-Phosphorus Ortho	<	.02	mg/L	.01	4500PE	9/13/00	14:00	59554	JAS	DUP	None Detected
QC-Phosphorus Ortho		.23	mg/L	.01	4500PE	9/13/00	14:00	59554	JAS	SPK .2	
					Reference Method: 4500 P E Ascorbic Acid						
E Coli Beaches		13,300.00	/100		9213D	9/13/00	13:00	59050	KK		
					Reference Method: 9213 D Natural Bathing Beach Escherichia coli						

1. For bacteriological results, "<" or "none detected" indicates negative.
2. Zeros to the right of the decimal point and/or to the right of a digit are not significant. IE: 10.00=10; 1.00=1; 1.10=1.1

All testing is conducted in accordance with Turner Technologies, Inc. "Quality Control / Quality Assurance Manual" and the the following regulations as applicable: 40 CFR Part 136, 40 CFR Part 261 or PL 91-597.

Approved by: David M Turner

SAMPLE RESULTS

Client Name: J.F. New & Associates
Client Project: Chapman Lake

Report Date: 10/19/00
EIS Order No: 001000131

EIS Lab Number	Client Description	Sample Date	Parameter	Result	Units	SDL	Test Date	Analyst	Method
071730	#1	10/12/00	Coliform,E.Coli	100	col/100ml	0	10/12/00	ClarkS	40CFR141
071731	#2	10/12/00	Coliform,E.Coli	8300	col/100ml	0	10/12/00	ClarkS	40CFR141
071732	#3	10/12/00	Coliform,E.Coli	100	col/100ml	0	10/12/00	ClarkS	40CFR141
071733	#3a	10/12/00	Coliform,E.Coli	320	col/100ml	0	10/12/00	ClarkS	40CFR141
071734	#3b	10/12/00	Coliform,E.Coli	690	col/100ml	0	10/12/00	ClarkS	40CFR141
071735	#4	10/12/00	Coliform,E.Coli	50	col/100ml	0	10/12/00	ClarkS	40CFR141
071736	#5	10/12/00	Coliform,E.Coli	100	col/100ml	0	10/12/00	ClarkS	40CFR141
071737	#6	10/12/00	Coliform,E.Coli	420	col/100ml	0	10/12/00	ClarkS	40CFR141

APPENDIX 7:

Historic Water Quality Parameters
Including Volunteer Monitoring Data
for Big Chapman Lake

Summary of Historic Water Quality Data for Big Chapman Lake

Sample Date	Secchi Disk (ft)	pH Epi / Hypo*	Total Phos. (mg/L)* Epi / Hypo	Alkalinity (ppm) Epi / Hypo	Chlorophyll	Data Source
06/04/64	12.0			145 / 138		McGinty, 1964
05/20/65		8.3 (epi)		136 (epi only)		McGinty, 1965
07/04/73	10.0		0.01			IDEM, 1986
08/09/76		9.0/ 7.5		136.8 / 222.3		Shipman, 1976
04/24/89	9.5					Volunteer monitor
05/05/89	11.3					Volunteer monitor
05/19/89	19.8					Volunteer monitor
06/02/89	17.8					Volunteer monitor
06/16/89	12.3					Volunteer monitor
06/30/89	13.5					Volunteer monitor
07/14/89	9.5					Volunteer monitor
07/28/89	10.0					Volunteer monitor
08/11/89	8.3					Volunteer monitor
08/25/89	7.0					Volunteer monitor
09/08/89	6.5					Volunteer monitor
09/22/89	6.3					Volunteer monitor
04/27/90	19.5					Volunteer monitor
05/11/90	12.5					Volunteer monitor
05/25/90	13.5					Volunteer monitor
06/08/90	17.0					Volunteer monitor
06/22/90	10.8					Volunteer monitor
07/06/90	6.3					Volunteer monitor
07/20/90	7.5					Volunteer monitor
08/03/90	7.3					Volunteer monitor
08/17/90	6.5					Volunteer monitor
08/31/90	8.0					Volunteer monitor
09/14/90	8.0					Volunteer monitor
09/28/90	7.5					Volunteer monitor
10/12/90	8.8					Volunteer monitor
06/01/91	12.5					Volunteer monitor
06/10/91	9.0	8.1 / 7.9		188 / 239		Pearson, 1991
06/15/91	7.0					Volunteer monitor
06/27/91	9.0					Volunteer monitor
07/12/91	7.0					Volunteer monitor
08/03/91	9.0					Volunteer monitor
08/16/91	9.0					Volunteer monitor
08/30/91	8.0					Volunteer monitor
09/20/91	6.5					Volunteer monitor
10/03/91	6.0					Volunteer monitor
10/13/91	7.5					Volunteer monitor
05/22/92	16.5					Volunteer monitor
06/05/92	18.0					Volunteer monitor
06/20/92	12.5		0.037		1.28	Volunteer monitor

07/11/92	8.0		0.058		1.80	Volunteer monitor
07/19/92	8.5					Volunteer monitor
08/02/92	8.5					Volunteer monitor
08/23/92	7.0		0.03		0.07	Volunteer monitor
09/14/92	7.5					Volunteer monitor
09/30/92			0.033		0.97	Volunteer monitor
10/02/92	7.0					Volunteer monitor
1992-1993	10.0		0.01			IDEM 305(b)report
05/27/93	13.0					Volunteer monitor
06/20/93	13.0		0.01		0	Volunteer monitor
07/11/93	9.0		0.01		1.25	Volunteer monitor
07/29/93	6.5					Volunteer monitor
08/13/93	8.0					Volunteer monitor
08/17/93	7.0		0.01		2.77	Volunteer monitor
09/16/93	8.0		0.017		5.49	Volunteer monitor
10/02/93	7.0		0.023		5.49	Volunteer monitor
05/20/94	13.0		0.011		1.39	Volunteer monitor
06/06/94	11.0		0.017		2.29	Volunteer monitor
06/24/94	8.0					Volunteer monitor
07/04/94	9.0					Volunteer monitor
07/05/94	8.0					Volunteer monitor
07/13/94	8.0		0.0275		2.56	Volunteer monitor
08/15/94			0.02		3.47	Volunteer monitor
08/15/94	2.7	8.4 / 7.6	0.014 / 0.055		3.22	CLP, 1994
08/19/94	9.0					Volunteer monitor
09/15/94	10.0		0.0405		2.82	Volunteer monitor
09/29/94	8.5					Volunteer monitor
10/08/94	11.0					Volunteer monitor
10/23/94	12.3					Volunteer monitor
05/12/95	10.0					Volunteer monitor
05/21/95	12.0		0.02		0	Volunteer monitor
06/10/95			0.018		4.58	Volunteer monitor
07/04/95	10.0					Volunteer monitor
07/17/95	8.0					Volunteer monitor
07/20/95	8.0		0.014		3.42	Volunteer monitor
08/13/95	10.5		0.004		0.21	Volunteer monitor
09/09/95			0.004		3.08	Volunteer monitor
05/16/96	6.0					Volunteer monitor
05/30/96	12.0					Volunteer monitor
06/27/96	12.5					Volunteer monitor
07/03/96	8.0					Volunteer monitor
07/14/96	7.0		0.023		1.36	Volunteer monitor
07/29/96	12.0		0.027		1.98	Volunteer monitor
08/22/96	7.5		0.024		2.80	Volunteer monitor
09/17/96	7.0		0.024		4.03	Volunteer monitor
09/30/96	7.5					Volunteer monitor
05/17/97	9.6					Volunteer monitor
05/21/97	9.2		0.027			Volunteer monitor
06/27/97	8.2		0.018		2.73	Volunteer monitor

07/22/97	7.7		0.017		4.47	Volunteer monitor
08/04/97	7.7					Volunteer monitor
08/17/97	8.0		0.021		5.91	Volunteer monitor
08/31/97	9.2					Volunteer monitor
09/13/97	9.3					Volunteer monitor
10/05/97	12.2					Volunteer monitor
05/12/98	16.2					Volunteer monitor
05/23/98	14.0		0.024		0.99	Volunteer monitor
06/07/98	10.2					Volunteer monitor
06/18/98	10.1		0.017		2.17	Volunteer monitor
06/30/98	3.1	8.3 / 7.5	0.015 / 0.025		2.58	CLP, 1998
07/06/98	7.5					Volunteer monitor
07/31/98	9.2		0.012		0.17	Volunteer monitor
08/20/98	9.6		0.016		1.83	Volunteer monitor
09/12/98	9.2					Volunteer monitor
10/08/98	9.9					Volunteer monitor
05/09/99	12.2					Volunteer monitor
05/26/99	10.2		0.035		0.37	Volunteer monitor
06/01/99	12.0	8.9 / 8.2		137 / 137		Pearson, 1999
06/09/99	15.8					Volunteer monitor
06/23/99	15.4		0.032		8.17	Volunteer monitor
07/07/99	8.4					Volunteer monitor
07/22/99	10.3		0.054		1.56	Volunteer monitor
08/13/99	6.9					Volunteer monitor
08/25/99	9.2		0.043		2.14	Volunteer monitor
09/13/99	6.6					Volunteer monitor
09/27/99	7.2					Volunteer monitor
10/10/99	11.9					Volunteer monitor
05/08/00	14.1					Volunteer monitor
05/26/00	17.3		0.047		0.20	Volunteer monitor
06/19/00	10.1		0.061		2.20	Volunteer monitor
07/03/00	9.0					Volunteer monitor
07/24/00	6.1		0.035		1.97	Volunteer monitor
08/07/00	2.3	8.4 / 7.6	0.03 / 0.082		1.77	Present Study
08/14/00	7.8		0.049		1.58	Volunteer monitor
09/07/00	7.6					Volunteer monitor
09/20/00	7.7					Volunteer monitor
10/17/00	11.1					Volunteer monitor

*epilimnetic values unless a hypolimnetic value is included after the /

APPENDIX 8:

Chapman Lakes Fish Species Lists

Fish species list by survey/study year for Big Chapman Lake. An x indicates the presence of the species for that year's survey.

Common Name	Scientific Name	1964	1976	1991	1999
Banded killifish	*Fundulus diaphanus*			x	x
Black crappie	*Pomoxis nigromaculatus*	x	x	x	x
Blackside darter	*Percina maculata*				x
Bluegill	*Lepomis macrochirus*	x	x	x	x
Bluntnose minnow	*Pimephales notatus*			x	x
Bowfin	*Amia calva*	x		x	x
Brook silversides	*Labidesthes sicculus*			x	x
Brown bullhead	*Ameirus nebulosus*	x	x	x	x
Carp	*Cyprinus carpio*	x	x		x
Central mudminnow	*Umbra limi*			x	x
Channel catfish	*Ictalurus punctatus*				x
Gizzard shad	*Dorosoma cepedianum*	x	x	x	x
Golden redhorse	*Moxostoma erythrurum*	x			x
Golden shiner	*Notemigonus chrysoleucas*	x	x	x	x
Grass pickerel	*Esox americanus*	x	x	x	x
Green sunfish	*Lepomis cyanellus*	x			x
Hybrid sunfish	*Lepomis* sp.				x
Johnny darter	*Etheostoma nigrum*			x	
Lake chubsucker	*Erimyzon succetta*	x	x	x	x
Largemouth bass	*Micropterus salmoides*	x	x	x	x
Logperch	*Percina caprodes*		x	x	x
Longear sunfish	*Lepomis megalotus*	x	x	x	x
Longnose gar	*Lepisosteus osseus*	x	x	x	x
Northern pike	*Esox lucius*	x	x	x	x
Pumpkinseed	*Lepomis gibbosus*	x	x		x
Redear sunfish	*Lepomis microlophus*	x	x	x	x
Rock bass	*Ambloplites rupestris*	x	x	x	x
Spotted gar	*Lepisosteus oculatus*	x	x	x	x
Spotted sucker	*Minytrema melanops*	x	x		
Steelcolor shiner	*Cyprinella whipplei*			x	
Walleye	*Stizostedion vitreum*	x	x	x	
Warmouth	*Lepomis gulosus*	x	x	x	x
White bass	*Morone chrysops*		x	x	x
White catfish	*Ameirus catus*		x		x
White crappie	*Pomoxis annularis*		x		
White sucker	*Catostomus commersoni*	x	x	x	x
Yellow bullhead	*Ictalurus natalis*	x	x	x	x
Yellow perch	*Perca flavescens*	x	x	x	x

Source: IDNR Fisheries Reports

Fish species list by survey/study year for Little Chapman Lake. An x indicates the presence of the species for that year's survey.

Common Name	Scientific Name	1964	1969	1976	1999
Black crappie	*Pomoxis nigromaculatus*	x	x	x	x
Bluegill	*Lepomis macrochirus*	x	x	x	x
Bluntnose minnow	*Pimephales notatus*		x		x
Bowfin	*Amia calva*	x	x	x	x
Brook silversides	*Labidesthes sicculus*	x	x	x	x
Brown bullhead	*Ameirus nebulosus*	x	x	x	x
Carp	*Cyprinus carpio*	x	x	x	x
Central mudminnow	*Umbra limi*		x	x	x
Channel catfish	*Ictalurus punctatus*		x	x	
Gizzard shad	*Dorosoma cepedianum*	x	x	x	x
Golden shiner	*Notemigonus chrysoleucas*	x	x	x	x
Grass pickerel	*Esox americanus*	x	x	x	x
Green sunfish	*Lepomis cyanellus*	x		x	
Hybrid sunfish	*Lepomis* sp.				x
Lake chubsucker	*Erimyzon succetta*	x	x	x	x
Largemouth bass	*Micropterus salmoides*	x	x	x	x
Logperch	*Percina caprodes*				x
Longear sunfish	*Lepomis megalotus*	x	x	x	x
Northern pike	*Esox lucius*				x
Pumpkinseed	*Lepomis gibbosus*	x	x	x	x
Redear sunfish	*Lepomis microlophus*	x	x	x	x
Shortnose gar	*Lepisosteus platostomus*	x			
Spotted gar	*Lepisosteus oculatus*	x	x	x	x
Spotted sucker	*Minytrema melanops*	x		x	
Walleye	*Stizostedion vitreum*	x	x		
Warmouth	*Lepomis coronarius*	x	x	x	x
White bass	*Morone chrysops*				x
White catfish	*Ameirus catus*			x	
White crappie	*Pomoxis annularis*	x		x	x
White sucker	*Catostomus commersoni*	x	x	x	
Yellow bullhead	*Ameirus natalis*	x	x	x	x
Yellow perch	*Perca flavescens*	x	x	x	x

Source: IDNR Fisheries Reports

APPENDIX 9:

Chapman Lakes Macrophyte Species List

Macrophyte Species List for the Chapman Lakes. An X indicates the presence of the species for that survey time. Source: Historical data obtained from IDNR fisher surveys. 2000 data obtained during macrophyte survey conducted by J.F. New ecological services department.

Species: Common name (*Scientific name*)	**Historical**	**2000**
Algae:		
Chara (*Chara sp.*)	X	X
Filamentous	X	X
Floating:		
Spatterdock (*Nuphar advena*)	X	X
White water lily (*Nymphaea odorata)*		X
Duckweed (*Lemna spp.*)	X	X
Submerged:		
Elodea (*Elodea canadensis*)	X	
Bushy Pondweed (*Najas flexis*)	X	
Leafy pondweed (*Potamogeton foliosus*)	X	
Largeleaf pondweed *(Potamogeton amplifolius*)	X	
Eel grass or Wild celery (*Vallisneria americana*)	X	X
Curly leaf pondweed (*Potamogeton crispus*)	X	X
Coontail (*Ceratophyllum demersum*)	X	X
Brittle naiad (*Najas minor)*	X	
Sago pondweed (*Potamogeton pectinatus*)	X	X
Northern milfoil (*Myriophyllum exalbescens*)		
Eurasian water milfoil (*Myriophyllum spicatum)*	X	X
Illinois pondweed (*Potamogeton illinoensis*)		X
Grassy pondweed (*Potamogeton gramineus)*		X
Slender naiad (*Najas flexilis*)		X
Emergent:		
Cattail (*Typha sp.)*	X	X
Water willow (*Justicia americana)*	X	X
Arrowhead *(Sagittaria latifolia*)	X	
Bulrush (*Scirpus sp.*)	X	X
Loosestrife (*Decodon sp*.)	X	X
Purple loosestrife (*Lythrum salicaria*)		X
Pickerelweed (*Pontederia cordata*)	X	X
Water lily (*Nymphae*)	X	X
Soft rush (*Juncus effusus*)	X	
Water shield (*Nuphar microphyllum*)	X	
Rose mallow (*Hibiscus sp.)*		X
Button bush (*Cephalanthus occidentalis)*		X
Jewelweed (*Impatiens capensis*)		X
Bladderwort (*Utricularia cornuta)*		X
Shrubs and Trees:		
Dogwood (*Cornus obliqua)*		X

APPENDIX 10:

Additional Funding Sources

ADDITIONAL FUNDING

There are several cost-share grants available from both state and federal government agencies specific to watershed management. Lake associations and/or Soil and Water Conservation Districts can apply for the majority of these grants. The main goal of these grants and other funding sources is to improve water quality though specific BMPs (best management practices). As public awareness shifts towards watershed management these grants will become more and more competitive. Therefore, any association interested in improving water quality through the use of grants must become active soon. Once an association is recognized as a "watershed management activist" it will become easier to obtain these funds repeatedly. The following are some of the possible major funding sources available to lake associations for watershed management.

Lake and River Enhancement Program (L.A.R.E.)

This is the program that funded this diagnostic study. L.A.R.E. is administered by the Indiana Department of Natural Resources, Division of Soil Conservation. The program's main goals are to control sediment and nutrient inputs to lakes and streams and prevent or reverse degradation from these inputs through the implementation of corrective measures. Under present policy, the L.A.R.E. program may fund lake specific construction actions up to $100,000 for a specific project or $300,000 for all projects on a specific lake or stream. Cost-share approved projects require a 0-25% cash or in-kind match, depending on the project. L.A.R.E. also has a "watershed land treatment" component that can provide grants to SWCD's for multi-year projects. The funds are used on a cost-sharing basis with farmers who implement various BMP's.

Clean Water Act Section 319 Nonpoint Source Pollution Management Grant

The 319 Grant program is administered by the Indiana Department of Environmental Management (IDEM), Office of Water Management, Watershed Management Section. 319 is a federal grant made available by the Environmental Protection Agency (EPA). 319 grants fund projects that target nonpoint source water pollution. Nonpoint source pollution (NPS) refers to pollution originating from general sources rather than specific discharge points (Olem and Flock, 1990). Sediment, animal and human waste, nutrients, pesticides, and other chemicals resulting from land use activities such as mining, farming, logging, construction, and septic fields are considered NPS pollution. According to the EPA, NPS pollution is the number one contributor to water pollution in the United States. To qualify for funding, the water body must be listed in the state's 305(b) report as a high priority water body or be identified by a diagnostic study as being impacted by NPS pollution. Funds can be requested for up to $300,000 for individual projects. There is a 25% cash or in-kind match requirement.

Section 104(b)(3) Watershed Protection Grant

The Watershed Protection Grant program is funded by the EPA and is administered locally by IDEM. These grants provide funding for the reduction and elimination of pollution within a targeted watershed. Priorities for funding include wetland/watershed protection demonstration projects, river corridor and wetland restoration projects, wetland conservation plans, assessment and monitoring plans, and wetland assessment models. The awarded amount can vary by project and there is a required 25% match.

Watershed Protection and Flood Prevention Program

The Watershed Protection and Flood Prevention Program is funded by the U.S. Department of Agriculture (USDA) and is administered by the Natural Resources Conservation Service (NRCS). Funding targets a variety of watershed activities including watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in small watersheds (250,000 or fewer acres). The program covers 100% of flood prevention construction costs or 50% of construction costs for agricultural water management, recreational, or fish and wildlife projects.

Conservation Reserve Program

The Conservation Reserve Program (CRP) is funded by the USDA and administered by the Farm Service Agency. CRP is a voluntary, competitive program designed to encourage farmers to establish vegetation on their property in an effort to decrease erosion, improve water quality, or enhance wildlife habitat. The program targets farmed areas that have a high potential for degrading water quality under traditional agricultural practices or areas that might make good habitat if they were not farmed. Such areas include highly erodible land, riparian zones, and farmed wetlands. Participants in the program receive cost share assistance for any plantings or construction as well as annual payments for any land set aside.

Wetlands Reserve Program

The Wetlands Reserve Program (WRP) is funded by the USDA and is administered by the NRCS. WRP is a subsection of the Conservation Reserve Program. This voluntary program provides funding for the restoration of wetlands on agricultural land. To qualify for the program, land must be restorable and suitable for wildlife benefits. This includes farmed wetlands, prior converted cropland, farmed wet pasture, farmland that has become a wetland as a result of flooding, riparian areas which link protected wetlands, and the land adjacent to protected wetlands that contribute to wetland functions and values. Landowners may place permanent or 30-year easements on land in the program. Landowners receive payment for these easement agreements. Restoration cost-share funds are also available. No match is required.

North American Wetland Conservation Act Grant Program

The North American Wetland Conservation Act Grant Program (NAWCA) is funded and administered by the U.S. Department of Interior. This program provides support for projects that involve long-term conservation of wetland ecosystems and their inhabitants including waterfowl, migratory birds, fish and other wildlife. The match for this program is on a 1:1 basis.

Wildlife Habitat Incentive Program

The Wildlife Incentive Program (WHIP) is funded by the USDA and administered by the NRCS. This program provides support to landowners wanting to develop and improve wildlife habitat on private lands. Support includes technical assistance as well cost sharing payments. Those lands already enrolled in WRP are not eligible for WHIP. The match is 25%.

In addition to these federal and state funded grants there are several private organizations that provide grants to parties interested in maintaining or restoring the watershed where they live. For more information on private grant foundations visit the web site www.fdncenter.org.

APPENDIX 11:

Letter from Kosciusko County
Soil and Water Conservation District
Re: Chapman Lakes Inlets

United States
Department of
Agriculture

Natural Resources
Conservation
Service

217 E. Bell Dr.
Warsaw, In.
46580

Nov. 05, 1997

Mrs Elaine Bertsch, Chairperson
Chapman Lake Conservation Club

Dear Elaine,

This letter is in response to your request for us to investigate the problems with high flow and sedimentation of three stream outlets into the Chapman Lakes.

First I have to apologize for taking so long to prepare this response, since it was a year ago this month when you made the request. I began work on this project right away, but then two employees transferred from our office in late 1996 and that has put me behind on many things in 1997. It has been brought to my attention by lakefront residents that the problem on at least one outlet has worsened considerably in the last year.

With the help of Roger Roeske, NRCS Ag. Engineer, I have prepared a narrative, for each of the three outlets, which describes the problems and provides some preliminary engineering design data. This design data is not final, and due to our workload and our agency's policy about competing with private engineers, we will not be able to provide a complete design.

If the Conservation Club wants to pursue an engineering design for any or all three of the outlets, I suggest that you apply for cost sharing assistance through the IDNR Lake and River Enhancement (LARE) Program. LARE can pay up to 90% of the cost of engineering design for problems such as yours. A request for LARE assistance would need to be made before the end of January. I would be happy to make arrangements for the proper LARE staff to meet with your officers to explain more about the cost share programs for the design phase and the construction phase, if you request.

Outlet # 1 is commonly referred to as Crooked Creek and enters Big Chapman Lake on the east shore. This is the largest stream that enters the lake with a drainage area of approximately 850 acres. This subwatershed is predominantly agricultural with a 35 acre campground near the lake. The soils in the upper part of the watershed are sandy loams on the surface with loam to clay loam glacial till at a depth of 24 - 30 inches. In the lower part of the watershed, near the lake, the soils change to more sand on the surface with sand and gravel below.

Some sheet and rill erosion is occurring on cropland in the watershed. As time allows we will visit the farmers in this watershed to offer conservation planning assistance to reduce the cropland erosion.

The gradient of this stream is relative flat in the upper part with approx. 20 feet of fall in the upper two thirds of its length and much steeper with 25 feet of drop in the lower third of the stream near the lake. This lower portion of the stream, which flows through the campground, meanders wildly due to the high velocity of its water. Considerable stream bank and stream bed erosion is occurring through this lower portion of the stream. This combination of high stream velocity, unstable soils, and close proximity to the lake, has resulted in a large delta being formed in the lake at the mouth of the stream.

In addition to cropland erosion control, we recommend that sediment basins be constructed to intercept the stream flow above the lake. The best sediment filter for the lake would be to construct two sediment basins. One of these basins should be located near the eastern boundary of the campground and one should be located within the campground just upstream of the point where a smaller stream enters from the north. Both of these basins would need a combination of storage and/or conveyance capacity to handle approximately 600 cubic feet of water that would runoff of this watershed during a 4 inch storm. The eastern most basin might not be feasible if subsurface drain tiles in the farm fields east of county road 400 E. would be affected. A second option would be to build only one basin at the western most site within the campground. This option would not provide as much filtering capacity as two basins but it would help considerably and might be the only feasible option. If these basins could store 25% of the peak runoff, a 10ft. by 10 ft. concrete box inlet with a 54" diameter pipe outlet would be required in the dams. Each of these dams and structures could cost from $20,000 to $25,000 to construct.

Outlet # 2 The second stream that we evaluated enters Little Chapman Lake on the northeast shore. A sediment delta has deposited in the lake at the mouth of this stream. The delta, though not as large as the one at outlet #1, is significant. This stream has a smaller watershed of approximately 260 acres.The gradient of this watershed is more uniform from the top to the lake. The uppermost cropland portion of this watershed has had significant conservation treatment in recent years. It appears that much of the sediment that enters the lake is coming from the stream banks in the lower portion of the watershed below county road 325 E.

We explored one option to slow the peak discharge into this portion of the stream after storms, therefore slowing the water through the lower stream section and reducing streambank erosion. A weir type structure made of concrete or steel could be placed in the stream just west of county road 325 W. This structure would be designed to allow normal base flows to pass through it, but storm runoff would be diverted south of the ditch into the low lying area between the road and the woods. In this area a one half acre sediment basin and a six acre shallow water wetland could be constructed to intercept and treat the storm flow. The sediment basin would be 8 feet deep and the wetland would be 1 to 3 feet deep. After the storm water passes through the sediment basin and then the wetland for treatment, it would be returned to the stream via a pipe structure. This option would cost approximately $23,000 to $29,000.

Outlet # 3 The last outlet that we considered enters Little Chapman Lake on the southeast shore through Lozier's Campground. The problem with this outlet appears to be one of excessive flow rather than lake sedimentation. An existing concrete box drop structure, located within the campground, has been weakened by storm flow in the past and needs repair.

This stream drains 340 acres of mostly cropland that lays southeast of the lake. The overall gradient of this stream is considerably less than the first two streams described above. Like stream # 2 this watershed has had a considerable amount of conservation treatment of crop land since 1990 This conservation treatment combined with a more stable stream channel is the reason that this outlet is not experiencing sedimentation like the others.

To reduce storm flow through the campground and to the lake, a stormwater retention basin could be constructed in the low lying area just east of county road 300 E. We have calculated that a 18 feet high dam, 300 feet long, built across the drainageway could store 2.2 inches of runoff from the entire watershed. This is almost a 25 year, 24 hour storm for this area. The dam would have a minimum top width of 10 feet, a concrete or steel spillway and a 48" diameter pipe under the dam. We estimate the total cost of this proposed project to be in the $24,000 to $29,000 range. Due to the presence of the county road and the mobile homes and campers immediatley downstream of the proposed dam, this project could have a class "c" hazard classification which would elevate the engineering design criteria and increase the cost of the project. If you proceed with this project, the design engineer would determine the hazard class.

Please consider that all of the options that I have discussed would require that the various landowners would allow the use of their land for the projects or that the Conservation Club would somehow acquire the land through lease or purchase. Land acquisition costs have not been included in any of the costs listed for the above options.

In closing, let me say that the Chapman Lakes enjoy good water quality relative to most of the lakes in the area, mostly due to the small size of the lake's watershed.. With that said, we are both aware that there are acute, severe problems on 2 or 3 stream outlets. Solving these problems would have a very positive impact on the present and future water quality of the lakes. I hope the Conservation Club will pursue these options both locally and through the IDNR LARE Program. These problems are probably too large for any one individual to solve but a group, such as yours, along with local ansd state government could make it happen.

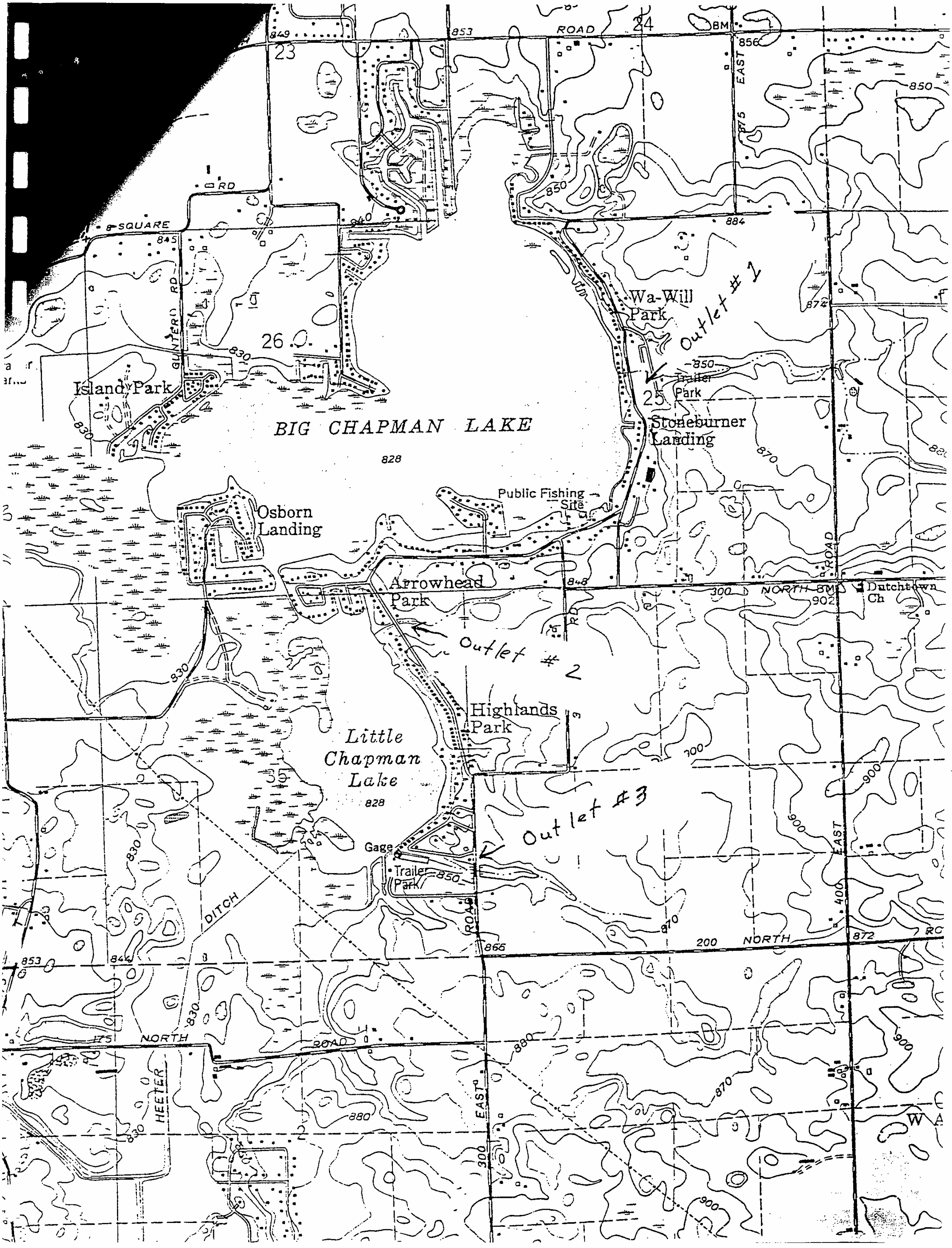
Please contact me if I can provide further assistance.

Sincerely yours,

Samuel E. St. Clair

Samuel E. St.Clair
District Conservationist.

CC Fanny Cozzi, Chapman Lake
Kent Tracy, IDNR, LARE
Mike Massone, IDNR, LARE
Jon Roberts, Kosc. SWCD
Dick Kemper, Kosc. Surveyor



BIG CHAPMAN LAKE
828
Little Chapman Lake
828
Island Park
Osborn Landing
Arrowhead Park
Highlands Park
Wa-Will Park
Trailer Park
Stoneburner Landing
Public Fishing Site
Gage
Trailer Park
Dutchtown Ch
Outlet # 1
Outlet # 2
Outlet # 3
ROAD
SQUARE
RD
GUNTER RD
EAST
EAST ROAD
300 NORTH
BM
200 NORTH
175 NORTH
ROAD
300 EAST ROAD
400 EAST
HEETER
DITCH
RD
23
24
25
26
35
849
853
856
850
875
840
845
884
874
830
870
848
902
900
866
872
853
844
880

APPENDIX 12:

Sediment Survey Report

Dredge Survey Report

Chapman Lakes, Kosciusko County, Indiana

I. Introduction

The Chapman Lakes receive drainage from approximately 4,566 acres of land that is predominantly in active agriculture. The Diagnostic Study (2001) documented several areas of sediment build-up at the mouths of inlet streams including Crooked Creek, Arrowhead Drain, and Highland Park Drain. The concentration of Eurasian water milfoil growth on top of the sediment has resulted in access problems for many of the homeowners adjacent to these inlet streams and nearby channels. The Diagnostic study recommended projects in each of these drainage areas to reduce the sediment loading into the lakes. To supplement the Diagnostic Study, this study was undertaken to document the extent, depth, and type of sediment at the mouths of all the inlets and channels in the lake.

II. Survey of Problem Areas

Five areas at the mouths of drains coming into the lakes were surveyed by probing the sediments with a 2-inch diameter PVC pipe marked in tenths of an inch. The depth of sediment build-up was based on the difference between the existing bottom and the original bottom of the lakebed determined by the depth of accumulated new material. Probes were made in a 50-foot grid pattern surrounding the mouths of inlet streams. Reported sediment depths were averaged for the entire grid. The five areas surveyed are discussed below in detail.

Area 1 – Nellie's Bay Peninsula, Big Chapman Lake

Nellie's Bay is located at the north end of Big Chapman Lake. It is a shallow bay with cattail-dominated wetlands making up the majority of the aquatic zone. The entrance into the bay is choked with milfoil on the west and has a healthy stand of hard stem bulrush on the east. While the area of hard stem bulrush is generally less than three feet in depth, it is not recommended for dredging because it is the natural bottom contour. The same is true of the milfoil choked west bank. This area needs milfoil control, not dredging. There is an artificially dredged access channel approximately 25 feet wide all along the east shore of Big Chapman Lake just south of Nellie's Bay (Figure 1). The channel is approximately 1300 feet long. The average depth of water in this channel is approximately 1.5 to 2 feet over several feet of organic matter. Dredging this channel would result in approximately 2400 cubic yards of dredge spoils and is only recommended if the residents desire better access to the lake. Dredging this channel would not serve an ecological function.

Area 2 – Crooked Creek Inlet, Big Chapman Lake

Crooked Creek drains approximately 775 acres of agricultural land and travels through an eroded forested area prior to entering the lake. A peninsula of sediment has formed at the mouth of the channel and completely blocks access along the shore (Figure 2). The plume of sediment is approximately 1/3 acre with an average sediment depth of 1.75 feet. At a point 150 feet from the shoreline, the depth of accumulated sediment was one foot, and the water depth was 2.2 feet. Two hundred feet south of the channel mouth at the same distance from shore, only two inches of sediment had accumulated covered by three feet of water. Dredging of this area to the natural bottom contours would yield approximately 1100 cubic yards of sand. This area is recommended for dredging after stabilizing Crooked Creek and controlling the sediment load. Dredging this sediment plume would have positive ecological and recreational functions.

Area 3 – Arrowhead Park Drain, Little Chapman Lake

Arrowhead Park receives runoff from approximately 303 acres. Sand and organic matter have accumulated in a plume stretching 150 feet into the lake and northward from the mouth of the drain almost 400 feet (Figure 3). This restricts access to the channels on either side of C19A road, as Eurasian water milfoil now dominates the shallow water. The 1.4-acre plume of sediment averages 3 feet in depth with the majority of sediment located directly in front of the channel mouth. The sediment depth tapers off to one foot at the north end of the plume. Dredging this area to the original bottom grade would result in approximately 4,000 cubic yards of material. This area is recommended for dredging in order to improve owner access to the channels.

Area 4 – Highland Park Drain, Little Chapman Lake

The Highland Park sub-watershed drains 121 acres of agricultural land. The drainage has delivered a plume of sediment to the lake that is approximately 75 feet wide and 200 feet long (1/3 acre, Figure 4). The plume stretches northwestward from the mouth of the drain. On average this plume of accumulated sediment is 1.5 feet deep covered by 1-2 feet of water. Dredging this area would result in approximately 833 cubic yards of sediment. It is recommended that this area be dredged to remove the accumulated sediment, which causes a boating restriction along the shoreline and supports dense milfoil beds.

Area 5 – Lozier Landing, Little Chapman Lake

Lozier Landing is the outlet for a creek that drains 838 acres of agricultural land into the southeast corner of Little Chapman Lake. Historically, the developer of the property has altered the stream before it reaches the lake by damming it into a pond, filling a portion of the floodplain, and excavating the final 500 feet into an access channel (Figure 5). Measurements taken 50 feet in front of the mouth of the channel documented a water depth of 6 feet over soft muck and marl bottom. No accumulated sediment was noted. A measurement midway into the channel noted 5 feet of water over the same muck substrate. Near the outfall from the drop structure the water depth was 3 feet with several inches of gravely sand over the muck. Dredging is not recommended in this channel at this time, as the water depths are adequate for boat access.

III. Disposal Areas

Dredging of the selected sites would require two separate disposal areas. Big Chapman Lake dredging areas are best served by a disposal area in the open farm fields east of Chapman Lake Drive, north of Crooked Creek, and south of 400 North Road (Figure 6). The disposal area would need to be approximately 1.5 acres.

Little Chapman Lake dredge areas are located off 300 East Road at C20 and C21. Pumping of spoils up the drainages of Arrowhead Park and Highland Park to an open farm field west of 325 East Road offers the most economical disposal solution. This disposal area would require approximately 2.0 acres of land.

IV. Costs

Cost assumes that the above dredge disposal sites will be available.

Dredging Sites	Dredging cost*	Disposal basin	Permitting **
Nellies Bay Channel	$20,800.00	Combined with Crooked Creek	$2,500.00
Crooked Creek	$11,250.00	$7,000.00	$2,500.00
Arrowhead Drain	$37,500.00	Combined with Highland Park	$2,500.00
Highland Park Drain	$11,250.00	$12,000.00	$2,500.00

- * An additional set up fee of $5,000.00 is charged for bringing the equipment to the lake. The cost can be divided between all sites on the lake if they are completed consecutively.
- ** Permitting for any/or all sites combined would be the same as for one site.
- Land lease fees not included in cost estimate.

V. Summary

Five areas in Big Chapman and Little Chapman Lake were sampled with a two-inch diameter PVC pipe for accumulated sediment depth. These areas included all the areas in the vicinity of streams entering Big and Little Chapman Lakes as well as the channel along the peninsula between Nellie's Bay and Big Chapman Lake. Dredging of four areas is recommended to restore the lake to its original bottom contour. The areas include Nellie's Bay, the mouth of Crooked Creek, the mouth of the creek flowing through Arrowhead Park, and the mouth of the Creek flowing through Highland Park. The total volume of sediments to be dredged in these areas is approximately 8300 cubic yards. The aerial extend of dredging at these four areas is 2.5 acres. The approximate costs to construct the disposal basins and complete the dredging will be approximately $102,300 plus land costs. Permits will be required from the IDNR in order to dredge these select areas. Permission to dispose dredged materials will have to be attained from landowners.

The dredging of these areas in the lakes is recommended to reduce the re-suspension of sediment-bound phosphorus from boat traffic and provide recreation benefits to boaters using the lake.

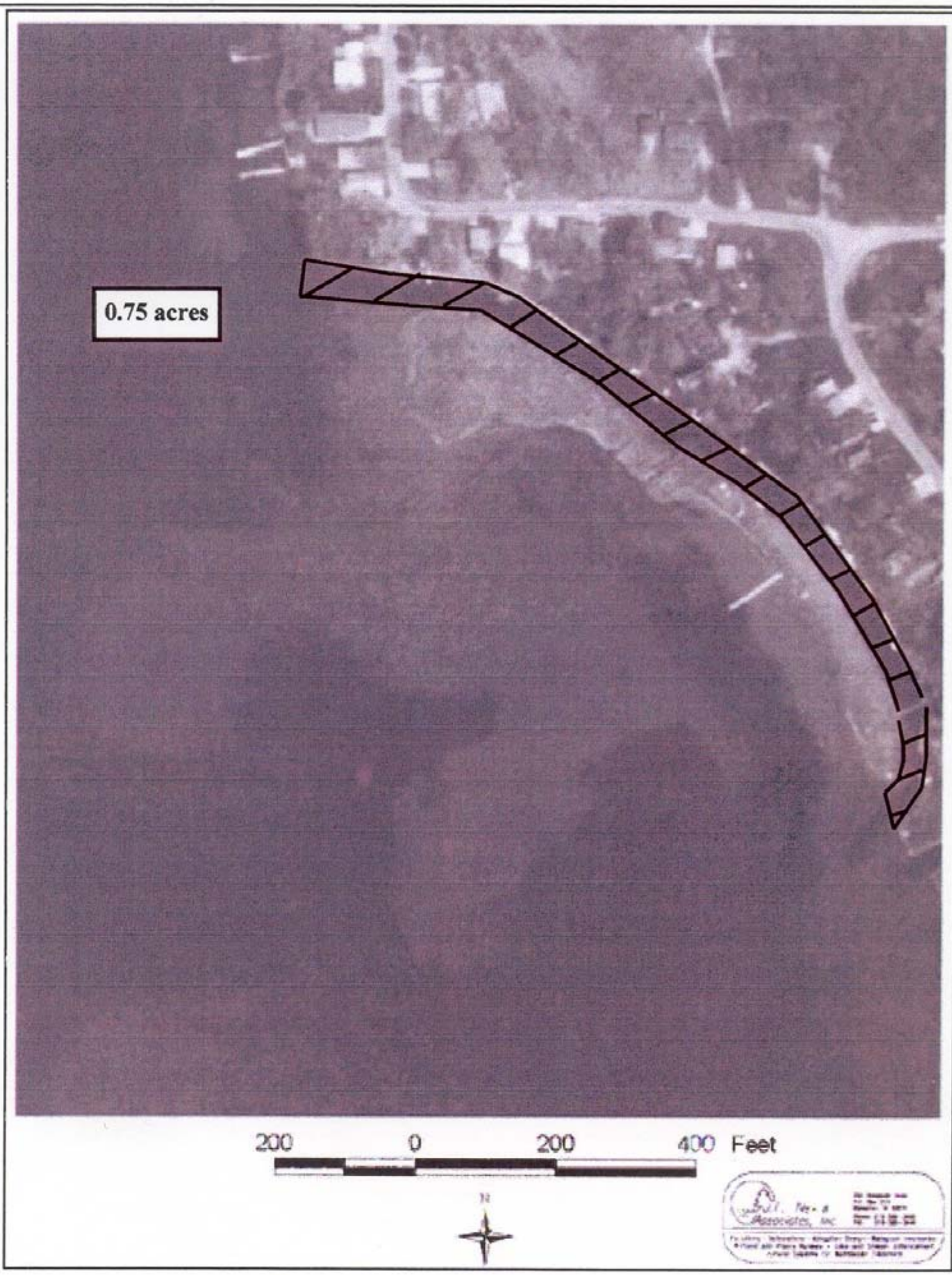


Figure 1: **Area 1 – Nellie's Bay**
Dredging Survey
Chapman Lakes
Kosciusko County, Indiana

JFNA#: 99-04-01

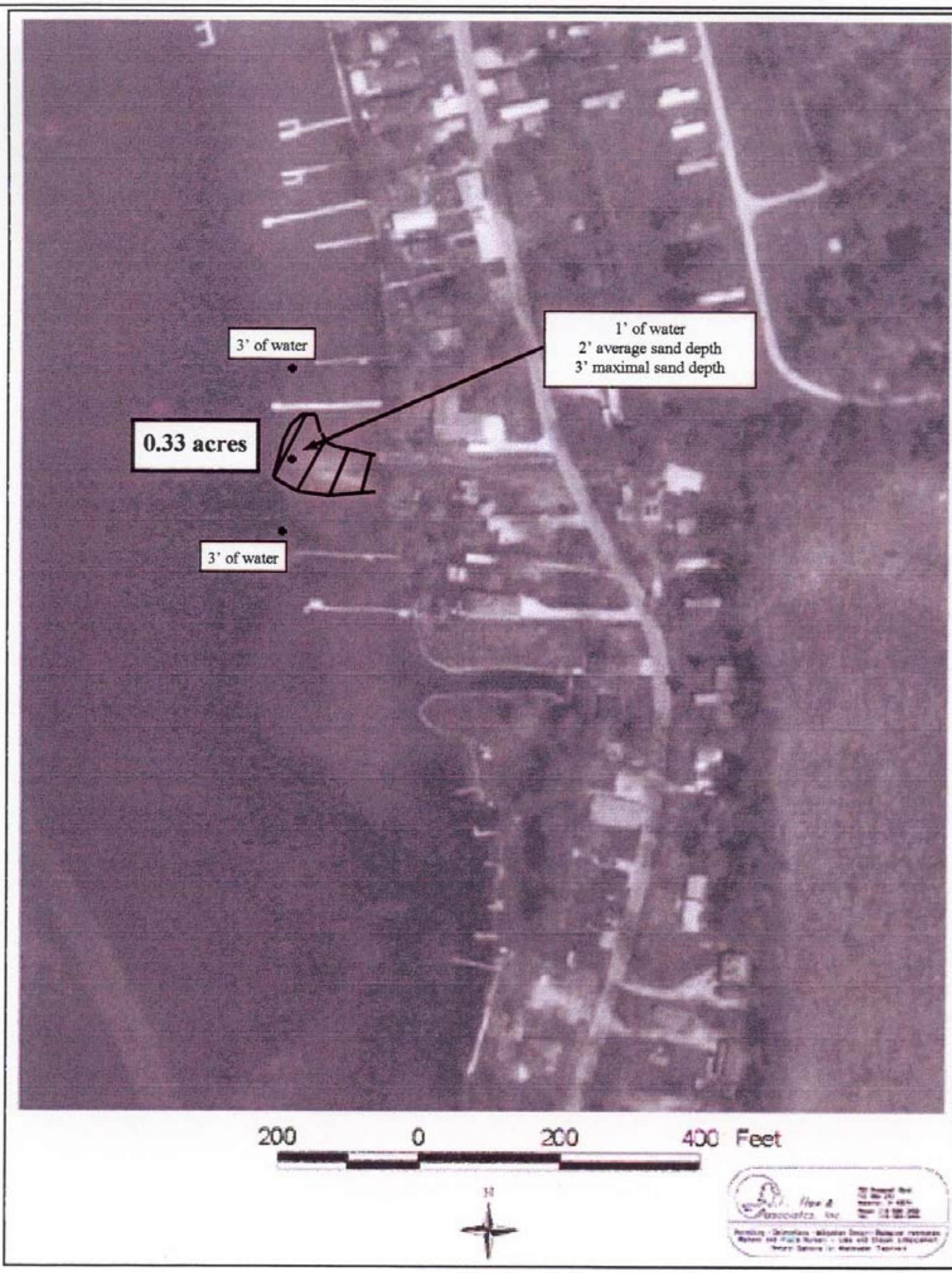
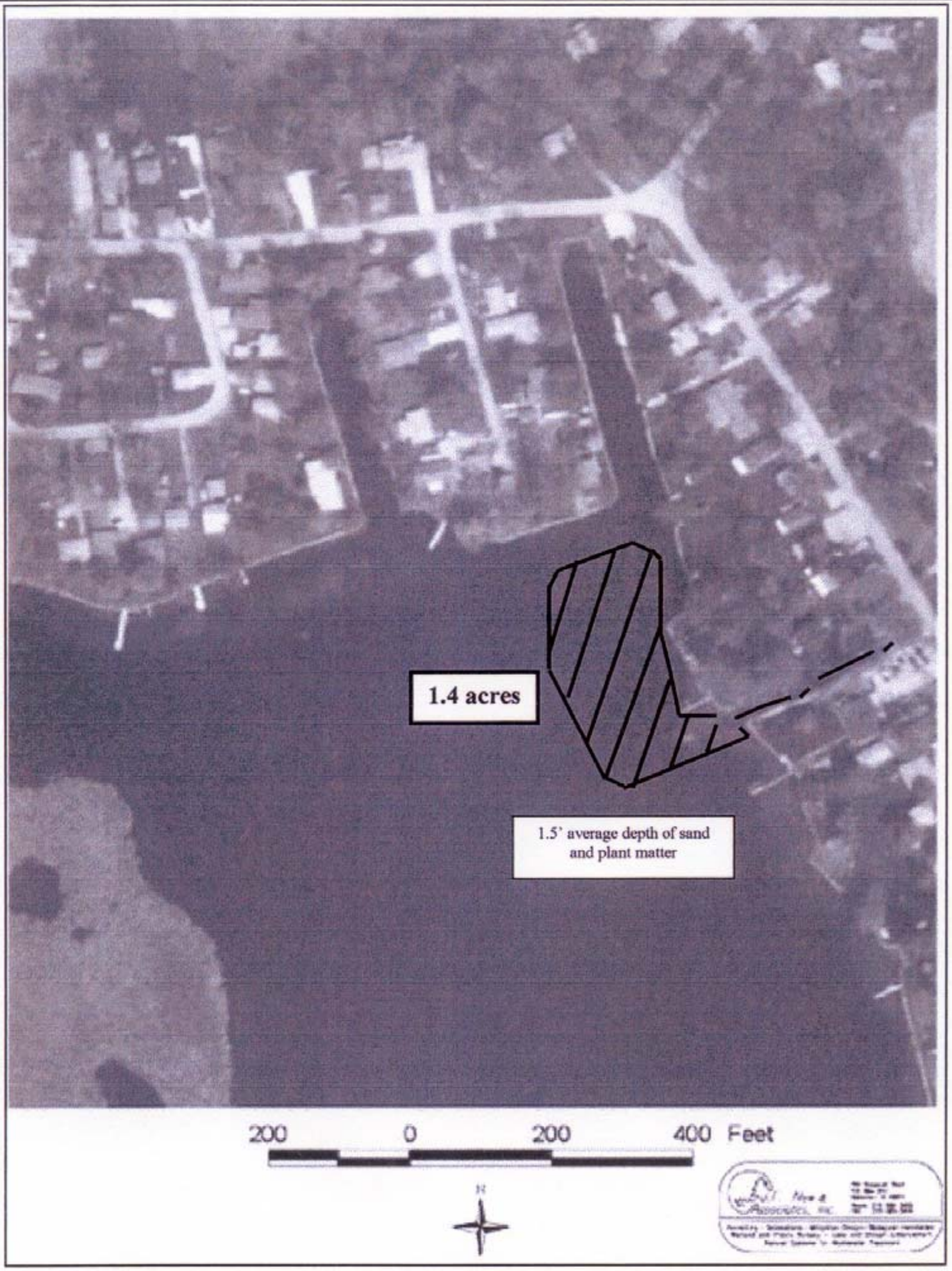


Figure 2: **Area 2 – Crooked Creek**
Dredging Survey
Chapman Lakes
Kosciusko County, Indiana

JFNA#: 99-04-01



JFNA#: 99-04-01

Figure 3: **Area 3 – Arrowhead Drain**
Dredging Survey
Chapman Lakes
Kosciusko County, Indiana

JFNA#: 99-04-01

Figure 4: **Area 4 – Highland Park Drain**
Dredging Survey
Chapman Lakes
Kosciusko County, Indiana

Figure 5: **Area 5 – Lozier Landing**
Dredging Survey
Chapman Lakes
Kosciusko County, Indiana

JFNA#: 99-04-01